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CONTENTS

	Page
Cultural and Spiritual Progress of Mankind	589
The Einstein Enigma. By Prof. G. C. McVittie, O.B.E.	591
The Cavity Magnetron. By Prof. J. T. Randall, F.R.S.	591
Psychology and Mysticism. By Mrs. D. M. Wheatley	592
Quasi-Abelian Functions. By L. Roth	593
Blood Pressure	593
The Behaviour of Seeds. By Dr. S. Clay	594
Studies of the Structure of Synthetic Polypeptides. By Prof. W. T. Astbury, F.R.S., Dr. Charles E. Dalgliesh, S. E. Darmon and Dr. G. B. B. M. Sutherland	596
Colour and Colour Vision in Animals. By Dr. G. S. Carter	600
Physiology of Lactation	601
Primitive Techniques, Agriculture and Economic Organisation	602
News and Views	604
Letters to the Editors :	
Structure of Calciferol.—Dr. Dorothy Crowfoot, F.R.S., and Dr. J. D. Dunitz	608
Surface Layers of Crystals.—P. B. Hirsch and the late Dr. J. N. Kellar	609
Ionization in Liquid and Solid Argon.—G. W. Hutchinson	610
Sound Velocity and Temperature Change of Molecular Association.—Prof. A. Van Itterbeek and A. de Bock	611
Magnetism of Celestial Bodies and Gravitation.—J. Marizni	612
Sidereal Variations of Cosmic Rays.—A. R. Hogg	613
Dielectric Properties of Titanates at Ultra-high Frequencies.—Dr. J. G. Powles	614
New Photoconductive Cells.—E. Schwarz	614
Hydrogen Peroxide and the Indirect Effect of Ionizing Radiations.—Miss Tikvah Alper	615
Air-Cored Synchrotron.—T. R. Kaiser and J. L. Tuck	616
Renal Regulation of the Extracellular Fluid.—Dr. Derek A. Denton	618
Isophosphorylase and the Formation of Branched Polysaccharides.—Dr. P. Bernfeld and A. Meutémédian	618
Microbiological Oxidation of Sterols.—Dr. A. Krámli and Dr. J. Horváth	619
The Sommelet Reaction.—Prof. C. W. Shoppee	619
Viscosity-Volume Relation for Ether.—A. Jobling	620
British Species of *Polycelis* (Platyhelminthes).—Dr. T. B. Reynoldson	620
Determination of Plant Densities.—Prof. M. S. Bartlett	621
Groundnut Breeding.—Dr. C. D. Darlington, F.R.S.	621
Anti-tubercular Activity of Oxidation Products of Substituted o-Phenylene Diamines. By Dr. Vincent C. Barry, J. G. Belton, M. L. Conalty and D. Twomey	622
Tenth International Limnological Congress, Zurich. By Prof. F. E. Fritsch, F.R.S.	623
Semiconductors and their Applications. By W. Grattidge and Dr. F. A. Vick, O.B.E.	624
Selection of Students for Universities	626
Morphological Astronomy	627
Social Sciences and Industrial Productivity	628

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CULTURAL AND SPIRITUAL PROGRESS OF MANKIND

MUCH of the Lambeth Conference report* deals with matters which are not the immediate concern of men of science as such; but two of the committee reports and certain passages in the Encyclical Letter are of interest in view of the increasing concern of the scientific world with the ethical aspects of atomic warfare, and of the attempts being made to formulate a professional code on the lines of the Hippocratic Oath. Moreover, a number of men of science have taken a prominent part in the movement to formulate a declaration of human rights, and on this also the report has something of interest to say. Thus even if their interest is indirect and by virtue of their citizenship rather than their professional activities, scientific workers cannot be altogether indifferent to any document that in any degree helps to clarify thought on the moral and spiritual values that form the real foundation for any attempt at union of the Western democracies. The frankness, clarity and logic of the whole report will indeed commend it to many outside the Anglican Communion, even if they do not always accept its premises or draw the same conclusions, at least without some reservations. The final invitation to all men and women to join in the war against the evils which wreck man's life and against the false creeds which debase it will be welcomed by many men of science.

The Encyclical Letter is noteworthy for a lucid restatement of the Christian doctrine of man as opposed both to Communism and nation worship. The claim for freedom is put in terms which many men of science will support, as they will welcome the insistence that rights imply duties which must be faithfully discharged. The Letter welcomes the great expansion of man's understanding of himself and of the world; but points out that knowledge may be used by man for self-destruction, and his greatest inventions turned to his ruin unless he learns to discipline his own nature and his powers. In forthright terms the claim that man should give himself entirely in obedience and service to the nation or group of which he is a member is rejected. Society exists to serve the needs of its members, not to enslave and possess them wholly, and the Letter maintains uncompromisingly that Christians must reject the Marxian Communism which exalts atheism and puts supreme confidence in material progress, and must condemn the cruelties, injustice and false propaganda inherent in it.

Neither the Letter nor the report as a whole fails to recognize that Communism to many people appears as a protest against social injustice, and it is urged in the report that it is the special duty of the Christian Church to oppose the Marxian challenge by sound teaching and the example of a better way. Firm support is also given to the work of the Commission of the United Nations on Human Rights. The Letter

* Lambeth Conference, 1948: The Encyclical Letter from the Bishops, together with Resolutions and Reports. Pp. v+53+iv+120. (London: Society for the Propagation of Christian Knowledge, 1948.) 5s.

also calls on all nations collectively to control the manufacture and use of atomic power, and to pledge themselves never to use it for the purposes of war; and it calls upon the nations even at the price of limiting their own sovereignty to work together to remove the causes of war and to promote human culture and welfare.

In one of its resolutions on the Church and war, the Lambeth Conference affirms that it is the duty of governments to work for the general reduction and control of armaments of every kind and for their final elimination, except those which may be necessary for international police protection. Nevertheless, it recognizes that in the meantime there are occasions when both nations and individuals may be obliged to resort to war as the lesser of two evils, though the present report adds little to what was said on this subject earlier this year in "The Church and the Atom", which was prepared by a commission appointed by the Archbishops of Canterbury and York. The report of the Committee on the Church and the Modern World shows that the thought of the Conference ran on similar lines to that of the Commission; although the report presents not so much a challenge to thought, as did that of the Commission, as a call to action to combat the present disastrous trend towards another world war. It rightly points to the danger in the growing fatalism on this subject, and reminds us we can have either war or civilization—not both.

The value of the United Nations Organisation is recognized; but it is pointed out that any such organisation must be permeated with moral and spiritual power. Again the report calls for endeavour to remove the causes of war by striving for greater economic well-being throughout the world, greater emphasis on social welfare, better observance of human rights in every sphere, and more constant use of international negotiation and conversation. Equally, the inherent danger of unbridled arrogant nationalism is faced. In the sections on the Church and the modern State, the challenge of dictatorship is repudiated as inconsistent with the Christian way of life and as offering an absolute conflict of values whether the basis of the dictatorship is a secular or a religious view of life; but it is not claimed that a parliamentary democracy is the only alternative to dictatorship in the modern world. On the contrary, a contribution is offered towards thinking out afresh the terms of co-operation, and towards a fresh experiment in co-operation, which merits the attention of all concerned with the problem of active democracy and the preservation of individuality and initiative under the present conditions of industry, commerce and society.

In a further section, there is a dignified and searching analysis of Communism which recognizes that Communism cannot be overcome by argument alone. It has to be outlived, not merely outfought. The positive suggestions made here should command approval and support far outside the Anglican Communion. To proclaim human rights without equivocation and respect them in practice; to do full justice to the truth in Communism; to recognize that the acceptance of an economic theory of Communism as distinct from Marxian atheism does not involve exclusion from the fellowship of the Christian Church; and to appreciate fully the immense contribution which science and technology have made to human welfare, and the dedicated lives of countless men of science and technicians—these are means which commend themselves to men and women of goodwill, and are already the basis of constructive contributions to human welfare and new experiments in communal living.

In the sphere of education, although there is little in the report that is new, there is much that will be welcomed. The most pressing need here, it is urged, is a *rapprochement* between religion and science, and the harnessing of scientific means to Christian ends. The Conference affirmed its belief that a fresh understanding of the nature and function of universities is greatly needed, and in that reassessment the place of theology in its full meaning must be duly considered.

Clearly it lay outside the scope of the Lambeth Conference to offer suggestions for dealing with such dangers as excessive specialization and the consequent lack of integration; but the report offers a real contribution towards supplying that clear sense of purpose the absence of which it regrets. The central problem of the relation of knowledge and power is fairly and squarely faced.

Through the new discoveries and inventions of our own time, man has gained power for the better ordering of the world. Those possessions now necessitate new forms of social organisation and the transcendence of outworn experiments in our ways of living and social institutions as the very condition of our survival. The over-riding task when all human values are threatened and man is being reduced to insignificance by forces beyond the individual's control is the vindication of man against all that cheapens or degrades him, and the rebuilding of a culture in which personal life holds the acknowledged primacy.

Whether or not they follow the argument of the report in its further searching and often stimulating analysis of man and his nature, scientific workers could scarcely wish for a fairer statement of the main issue. The Conference welcomed the great advance in scientific discovery characteristic of our age and repudiated the suggestion that any check should be placed upon it. Men of science, on their part, have also recognized that the consequent growth of man's knowledge increases his moral responsibility for the use and misuse of it. They will note with appreciation, also, the welcoming without reserve of the findings of scientific investigation into man's psycho-physical constitution, and the respect for the vocation of the man of science as a service to the God of truth. They, too, admit the desperate need for bringing technical discovery into true line with ethical direction, and that political freedom is everywhere in imminent danger because men shirk the price that must be paid for it and are prone to evade that responsibility, whether intellectual, civic or moral, by which alone it can be main-

tained. They, too, recognize that the hope that free institutions can be safeguarded on a secular basis must prove self-defeating, and some at least repudiate a determinist theory of history. If some cannot accept in their entirety the premises and conclusions of Christian thought even as displayed in the Lambeth Report, they may, none the less, be grateful for the evidence it affords of powerful support for many of the policies which they would wish to see pursued. The resolutions of the Conference may well lead to action and to the mobilization of moral and spiritual power behind the measures necessary no less for the furtherance of science than for the preservation of society and its highest cultural and spiritual values.

THE EINSTEIN ENIGMA

Einstein

His Life and Times. By Philipp Frank. Pp. 367. (London: Jonathan Cape, Ltd., 1948.) 16*s*. net.

THOSE who, like the present reviewer, are personally unacquainted with Einstein, will read this book with a shock of surprise. While Dr. Frank's sympathies are all with Einstein, the portrait presented to us is not altogether a pleasant one. We see a man developing early into the traditional type of nineteenth-century 'professor'. He regards himself as free to develop any eccentricity of behaviour, whether those about him like it or not, and to talk shop in season or out of season, a characteristic illustrated (p. 144) by the description of a courtesy visit to a non-mathematical colleague in Berlin, in which, after subjecting his hosts to a forty-minutes discourse on relativity, Einstein left abruptly. This lack of appreciation of the fact that ideas and interests which did not happen to interest him might still be as valuable as those that did may well explain Einstein's difficulties in the Berlin Academy, or his failings as a teacher. Always, apparently, ready to lecture on his researches of the moment or to deliver popular discourses, Einstein was not prepared to teach his students systematically what they had need to learn. An attitude of this kind is not incompatible with a deep concern for abstract causes such as pacificism or Zionism, and his lack of human contacts had one good result: it turned Einstein in the early 1920's from becoming a political leader of the Zionist movement. But there is another side to the picture: an impulsive kindliness made him only too ready to help refugee scholars after 1933, or to aid by correspondence a student in Prague (p. 331), or to instruct in arithmetic, at her own suggestion, a little girl of ten who lived near him in Princeton (p. 356).

Dr. Frank does not, of course, aim at an exposition of relativity theory; but he does describe Einstein's philosophical views in some detail (pp. 259 and 336). Einstein adopts a logical positivist view on the basic theoretical laws of Nature, which are for him free creations of the imagination confirmed by observation. Logically, this should lead to the acceptance of Newtonian mechanics as an equally good alternative to relativistic mechanics when we reflect on the enormous body of observational confirmation the former receive in engineering and astronomy, for example. At the same time, Einstein holds a realist view on electromagnetic and gravitational fields, light, atoms, electrons, etc. They are 'physical realities' and not concepts freely created for the purpose of interpreting observations. Nor is it easy to see how a belief in the rationality—almost the mathematical character—of Nature (p. 340) can be reconciled with his view of the character of scientific law. If Nature is rational, surely its laws are there to be discovered, and not created, by the man of science?

Dr. Frank's account of the times in which Einstein lived is written from the point of view of a Central European who sees Germany and her immediate geographical neighbours as the world-focus of scientific activities. Many quotations illustrate the strange vagaries of the totalitarian mind: in Nazi Germany relativity theory is the expression of Jewish physics, in Russia the theory is at first contrary to and later in accordance with dialectical materialism. Dr. Frank's selection among Einstein's contemporaries of those worthy of mention is very odd indeed. The venomous ideological crank, Philipp Lenard, is often referred to and freely quoted; but men who most nearly reached Einstein's intellectual stature and who developed and made known the theory of relativity receive scant attention. Hermann Weyl and de Sitter are not mentioned at all, and the three references to Eddington scarcely do justice to his contributions to the theory. Indeed, Einstein is credited (p. 326) with proving after 1933 that the geodesic principle is deducible from the field equations, though a proof of this theorem is to be found in the "Mathematical Theory of Relativity" written in 1923. Again, from pp. 346–351, we obtain the impression that the atom bomb was due to the scientific and political efforts of Einstein, O. Hahn, L. Meitner, E. Wigner, E. Fermi and L. Szilard. Even if Chadwick and Cockcroft are not worthy of mention, surely some native-born American physicists had a hand in the matter!

G. C. McVittie

THE CAVITY MAGNETRON

Microwave Magnetrons

Edited by George B. Collins. (Massachusetts Institute of Technology; Radiation Laboratory Series, Vol. 6.) Pp. xviii + 806. (New York and London: McGraw-Hill Book Co., Inc., 1948.) 54*s*.

THE origin and excellence of the Radiation Laboratory Series of monographs is now well known, and can need little in the way of introduction to the physicists and engineers on both sides of the Atlantic who took part in the great war-time venture of radar. Without the cavity magnetron it is more than doubtful whether micro-wave radar could have become the decisive weapon it turned out to be. In this sense, therefore, the volume under review is perhaps the most important of the series, providing the central theme without which many of the other volumes could not have been written.

The cavity magnetron as a micro-wave generator of pulsed power of the order of a few kilowatts was taken to the United States by Sir Henry Tizard and Prof. J. D. Cockcroft in May, 1940, in a form entirely suited to manufacture; and this after only a few short months of work by those concerned. This early work, the later use of higher peak voltages and magnetic fields, the introduction of strapping in 1941, and the later achievements of peak powers of 2 or 3 $\times$ 10^6 watts at a frequency of 3 $\times$ 10^9 mc./sec.,

are efforts of which British physicists and engineers in universities and in industry may be justly proud. Much also of the development of an adequate theory of the magnetron was carried out in Britain by Hartree and Stoner and their collaborators. The method of the self-consistent field so strikingly successful in atomic physics proved equally valuable in the theoretical study of the magnetron. The Physics Department of the University of Birmingham, under the direction of Prof. M. L. Oliphant, was the centre from which sprang much of the experimental scientific effort on magnetrons in Britain or any other country. Oliphant, and no doubt others, recognized at an early stage the significance of obtaining high powers at centimetre wave-lengths. The klystron at that time was limited by a comparatively low beam current, but had the advantage of cavity resonators. The basic problem at the end of 1939 was to decide on a device which would take advantage of an enclosed resonator system and be much less limited in current. The cavity magnetron was the answer. In looking back on this venture, I think it is fair to comment that no other war-time effort has shown so well the original approach of British men of science to new problems; for not one of the team there collected could claim to have any prior experience in the field of microwave generators.

The approach of the Radiation Laboratory to the problems of the magnetron, as to other aspects of radar, was, as a result of the pioneer work carried out in Britain, bound to be rather different. The great American effort on the magnetron was one largely, perhaps, directed to understanding, consolidation, and manufacture rather than new discovery; at least that is the way things turned out. There are, of course, exceptions to this, such as the 'rising-sun' magnetron, a development arising entirely from the Columbia Laboratories. The volume under review pays only a brief tribute in its early pages to the British effort on the magnetron, and gives little idea of how the work developed. The book is a detailed analysis of the properties and behaviour of the cavity magnetron; it is not the story of the magnetron, nor is it intended to be. But it is a pity that time could not have been found for a more adequate survey of the development of ideas, experimental results, and theories from the numerous N.D.R.C. and C.V.D. Reports available to the authors. "Microwave Magnetrons", in short, gives a tremendous impression of knowledge of the subject, but gives little idea of how that knowledge grew from stage to stage.

Like other volumes of the series, "Microwave Magnetrons" is not easy meat for the uninitiated. The book contains a good introduction by its editor G. B. Collins, and is thereafter divided into five parts: resonant systems; analysis of operation; design; tuning and stabilization; practice. Parts I, II, III each contain four chapters and Parts IV and V three chapters each. The purpose of Part I is a discussion of the fundamental electromagnetic properties of the resonant system and the output circuit. Three types of resonant circuit are dealt with: the unstrapped system, the rising-sun system, and the strapped system. In Part II the operation of the magnetron is analysed first by a study of the interaction of the electrons and the electromagnetic field; this is followed by chapters on the space charge as a circuit element, transient behaviour involving a discussion of the starting of oscillation; and a discussion of noise.

Part III opens with a valuable discussion of the principles of design, and lays emphasis not only on the fundamental parameters but also on those of importance to the user. A discussion on resonant systems, cathodes, and a short chapter on permanent magnets make up the remainder of Part III. Part IV is concerned with tuning and stabilization. Part V is devoted to American manufacturing methods, and as such is admirable. Chapter 19 describes typical magnetrons, all American. Those interested in the contributions of British science and engineering to the study and manufacture of the cavity magnetron will regret that more space could not have been found for a discussion of their efforts in this key volume, which remains, nevertheless, a most imposing monograph on 'the heart of radar'.

J. T. RANDALL

PSYCHOLOGY AND MYSTICISM

Hindu Psychology

Its Meaning for the West. By Swami Akhilananda. Pp. xviii + 241. (London: George Routledge and Sons, Ltd., 1947.) 12*s.* 6*d.* net.

THE title of Swami Akhilananda's book is misleading to the Western reader. It is not quite clear what he means by Hindu psychology. A clue is given in Prof. Brightman's introduction in which he says "The purpose of this book is not to lead him *to substitute Indian Psychology for Christianity or Judaism*". Hindu psychology is, then, something which could take the place of a religion.

Although the Swami does not define Hindu psychology, he states that its method is "training the total mind of the individual, including thought, emotion and will". This is an entirely different conception of method from that of the European and American schools of psychology. It is well to bear in mind when reading this book the enormous chasm separating the Hinduism of the cultured classes from that of the masses in India; and it must also be realized that Hinduism is not only a religion but also a social system, the basis of which is caste.

The essence of higher Hinduism is a belief in the unity of being. "Knowledge of eternal truth belongs to those and only those who see but One in the manifold changes of the Universe". This religious philosophy is evident in Swami Akhilananda's work.

The book begins with a very brief outline of Western schools of psychology which are not, in the author's opinion, concerned with the "total mind", an abstraction not defined. The psycho-analytic concept of two layers of mind is also considered inadequate. The Hindu psychologists recognize four states of consciousness: the sleeping and dreaming states, which are included in the subconscious of Western terminology, the conscious, and the superconscious. It is in its concern with the superconscious states (not to be confused with telepathy and clairvoyance) that Hindu psychology is unique.

The chapters dealing with meditation and its effects, insight, extra-sensory experiences, and the superconscious state, are the most interesting, but bewildering to the reader unaccustomed to Eastern mysticism.

The sincerity of Swami Akhilananda is obvious, and Western pride in its scientific attitude is shaken by this statement: "It is true that the Occidental

countries, with the help of scientific achievements, have done a great deal for the betterment of the everyday life of man. Yet in the West, because of the restlessness, unhappiness, and dissatisfaction of the mind, there are constant conflicts and frustrations resulting in extreme forms of mental disorders, nerve troubles, and functional ailments. This shows that the modern ways of life, based on scientific discoveries and their uses, have not solved the psychological problems of the West. On the other hand, the problems are becoming more and more frightening. So the West must find a way out of this dangerous situation".

D. M. WHEATLEY

QUASI-ABELIAN FUNCTIONS

Funzioni quasi-abeliane

By Prof. Francesco Severi. (Pontificiæ Academiæ Scientiarum Scripta Varia 4.) Pp. 327. (Rome: Pontifical Academy of Sciences, 1947.) n.p.

THE present treatise, constituting almost entirely an original work, was written during 1944–45 and communicated as a memoir to the Pontifical Academy of Sciences, by which it has been published as one of a series of monographs. Its purpose is to fill an obvious gap both in the theory of algebraic functions and their integrals and in the relevant geometrical literature, subjects to which Prof. Severi has made masterly contributions during the last forty-five years. The concept of quasi-Abelian function, in its simplest form, has its origin in a theorem of Weierstrass, which asserts that the only uniform functions of a complex variable possessing an algebraic addition theorem are the elliptic functions and their degenerate forms, namely, the exponential and rational functions. The functions of the last two types are the quasi-Abelian functions relative to the elliptic function.

In his treatise Severi is primarily concerned with the solutions of the generalized problem, that is, the uniform functions of any number of complex variables which possess an algebraic addition theorem; for solutions of the most general kind—the so-called Abelian functions—there already exists a very great literature extending over more than a century, but hitherto there has been no systematic treatment of the degenerate forms. As Severi shows, these are likewise periodic functions in general, though with fewer periods than the associated Abelian functions, and in many respects are strictly analogous to the Abelian functions themselves.

Severi's investigation is, naturally enough, in the tradition of the Italian school of algebraic geometry which, taking its cue from the Germans Brill and Noether, has translated the discoveries of Abel, Jacobi and Riemann concerning multiply-periodic functions into the language of the geometry of curves. For this purpose it employs a strikingly simple technique, depending on the consideration of sets of points on an algebraic curve, from which results not only a remarkable gain in elegance and power, but also a method capable of extension to similar problems of a more complex nature. To this method Severi has now added a concept which has already played an essential part in other researches of his: thus while, according to the classical theory, an algebraic plane curve of degree n, possessing d double points, has a genus p given by the formula $p = \frac{1}{2}(n-1)(n-2) - d$, Severi's innovation consists in regarding a certain number of these nodes as virtually non-existent, so that the curve has a *virtual genus* greater than p.

The first section of the treatise—about one-third of the whole—is in the nature of a prelude, devoted to the theory of series of points on a curve. The next two sections deal with the quasi-Abelian functions in all their generality, their periods, the associated integrals and allied geometrical results concerning the so-called Picard variety attached to a curve of genus p. Severi begins by posing three alternative definitions of the functions, and eventually shows that all three are equivalent to the one already stated above; here, it must be noted, certain parts of the theory hinge on a hypothesis of a geometrical character which has so far not been established. The last section, which is comparatively brief, completes an interesting chapter in the theory of surfaces. It is just forty years since Enriques and Severi wrote their prize memoir (*Acta Mathematica*, 1909–10) on hyperelliptic surfaces, that is, surfaces the coordinates of the points of which are expressible as uniform quadruply-periodic functions of two independent variables; an example is Kummer's quartic surface, which itself includes Fresnel's wave surface as a special case. The memoir has now been supplemented by a study of the quasi-hyperelliptic surfaces, which comprise Plücker's quartic surface, a familiar locus in line geometry; Severi shows how this is obtainable as a limiting form of Kummer's surface.

The book, which concludes with a detailed bibliography, is a notable addition to the distinguished author's publications, and will doubtless occupy a permanent place in the literature.

L. ROTH

BLOOD PRESSURE

Blood Pressure and its Disorders, including Angina Pectoris

By Dr. John Plesch. Second edition, revised and enlarged. Pp. xiv + 307 + 15 plates. (London: Baillière, Tindall and Cox, 1947.) 21*s.* net.

THE first edition of this book by Prof. Plesch will be well known to most workers interested in this subject, and a second edition of it will be welcomed. Most of the chapters have been enlarged and some new ones have been added; references to the literature and case-histories increase the value of the book, and suggestions made by readers of the first edition have been incorporated. The author says that he has dealt only with aspects of the subject of which he has had practical experience through research and observation, and that he does not intend to present the reader with a text-book. This note of personal experience is evident on every page. It is a book for the progressive and open-minded worker who shares its author's evident desire to understand thoroughly the origins of the diseases discussed and to relieve the suffering that they cause by treatment based upon this understanding.

A short review cannot give an idea of the wide field covered by the text. Planned in three main sections, one on arterial blood pressure, one on venous pressure and one on the much-discussed conception of angina pectoris, the book deals with the physiological basis of disorders of the blood-pressure, their diagnosis and the clinical application of the facts discussed. No doubt many readers will be especially interested in the section entitled "Angina Pectoris", partly because the author does not restrict the conception

of angina to spasms of the coronary arteries of the heart, but discusses it as "generally applicable to spontaneous cramps of any artery of the body".

We hear much nowadays about arteriosclerosis and high and low blood-pressures; but Prof. Plesch thinks that the danger of arteriosclerosis, at any rate, is over-estimated. Post-mortem examinations, made in different countries, of healthy young soldiers who fell in the First World War, show that 44·5 per cent of soldiers between the ages of twenty-one and thirty years of age and 62 per cent of those between thirty-one and forty years bore evidence of arteriosclerosis. These figures are surprising; but the mortality from this disease is only 6 per cent of the total mortality, and Prof. Plesch concludes that arteriosclerosis is not necessarily progressive and that it can be cured. During his valuable discussion of the general and symptomatic treatment of angina pectoris, he makes interesting observations on diet, the consumption of alcohol and smoking. Smokers will be especially interested in his analysis of various tobaccos and their effects.

An appendix discusses the use of the tonoscillograph and the interpretation of tonoscillograms, the author's techniques of auscultation and borderline percussion, the use of the blood-gas analyser with an absorption cell, and his experimental work on the immunization and sensitization of patients by injections of their own urine.

The book is well produced, and the photographic and other illustrations add much to its value.

THE BEHAVIOUR OF SEEDS

Twenty Years of Seed Research at Boyce Thompson Institute for Plant Research

By Lela V. Barton and William Crocker. Pp. 148 + 22 plates. (London: Faber and Faber, Ltd., 1948.) 21*s*. net.

FOR more than twenty years workers at the Boyce Thompson Institute at Yonkers, New York, have been publishing papers on the factors influencing the germination and continued viability of seeds. Their investigations have been not only of academic interest, but also of practical significance to people who produce, market, and sow seeds; and presumably it has been with this in mind that two of the senior workers concerned have now written a very brief summary of the Institute's work in this field. Farmers, gardeners and seedsmen will find this book giving, with a minimum of scientific terminology, confirmation, explanation and extension of much that they have discovered and guessed, and also some suggestive new facts.

Part 1 of the book reviews various types of delayed germination, due to the need for after-ripening, by drying, or by 'stratification' at low temperatures while moist, or to resistant seed coats, or to internal 'physiological' dormancy of root or shoot rudiments. The examples given underline the survival value of many of these peculiarities, and emphasize that sufficient knowledge of a plant's life-history and wild environment will provide a good basis upon which to forecast the conditions required for the most speedy and complete germination of its seeds. Apart from this, general principles are not easy to formulate. Although the seeds of related plants naturally tend to show similar behaviour, considerable variation can be found within the genus or even between varieties of the same species. In this wet harvest season of 1948 the British farmer is, once again, having thrust upon his notice the unfortunate readiness to 'sprout out' of the otherwise admirable wheat Holdfast, and the more stubborn initial dormancy of, for example, some varieties of Scandinavian origin. The same phenomenon is seen from another angle in the seed-testing laboratory, where freshly harvested wheats of the latter type are artificially dried at 40° C. as a matter of routine, or they tend to grow slowly and erratically in the test dishes.

A chapter, with the only plate in colour, is devoted to ways in which the capacity of seeds to germinate can be ascertained quickly without waiting for normal growth. The summary dismissal of chemical tests in favour of an excised embryo technique is unjustified. Unless the seed is large, the latter method requires a considerable amount of time and manipulative skill, and only yields results after some days; whereas sectioning of the soaked seed followed by treatment with a dilute aqueous solution of triphenyl tetrazolium chloride or bromide, a technique developed in Germany during the recent War, can give information in less than two hours, and has proved so practicable and reliable, at any rate with seed grain, that it is now regularly utilized by at least one commercial house.

Part 2 is concerned with the life-span of seeds and the effect on it of storage conditions, and here the authors are able to make the general recommendation that "rather low moisture content and/or low temperatures are effective for successful storage of vegetable seeds" and, in fact, of the majority of seeds. Here, again, generalization is unsafe. Barton and Crocker, for example, confirm the familiar observation that *Delphinium* seeds are short-lived unless specially stored. But 1938 seeds of *Delphinium denudatum* stored without special precautions and sown by the writer in 1939 and every year since, have shown the expected fall in percentage germination to very low in 1940, nil in 1941 and every subsequent year until, in 1948, the ten-year-old seed produced two sturdy plants! Storage of farm and garden seeds for a year or more is common commercial practice, but the normal 'carry-over' life of many seeds is insufficient to smooth out recurrent gluts and shortages, and it can be predicted that more experiment will almost certainly lead to the use of dried and thermostatically cooled air to increase the period of effective large-scale storage.

A number of photographs demonstrate impressively some of the points considered, and the frequent tables in the text are concise, easily interpreted summaries of the experimental results; although the serious student will note that many of them quote percentages only without actual numbers and are, therefore, not susceptible to statistical criticism. The references at the ends of the chapters appear to include only the papers by Boyce Thompson staff upon which the book is based, and might with advantage have been extended to include the more important relevant publications of other workers. A more serious limitation of this small book's usefulness may be imposed by the price, which even by to-day's standards is high. Perhaps its greatest merit is that it stimulates as well as illuminates, suggests not only how much but also how little is known, and this in one of the fields where a real contribution to knowledge can still be made by the enthusiastic individual with a minimum of time and equipment.

S. Clay

Scientists Starred 1903–1943 in "American Men of Science"

A Study of Collegiate and Doctoral Training, Birthplace, Distribution, Backgrounds and Developmental Influences. By Prof. Stephen Sargent Visher. Pp. xxiii+556. (Baltimore, Md.: Johns Hopkins Press; London: Oxford University Press, 1947.) 25*s*. net.

FOR forty-five years scientific workers of the United States have been starred for pre-eminence by their colleagues in the reference work "American Men of Science", first by a few outstanding leaders in twelve scientific subjects, and then by those who had already been starred. This volume gives an analysis of the life-histories of those who have been starred in terms of their scholastic and academic background, and such other factors as their birthplace, month of birth, reasons for taking up a scientific career and parentage.

So far as the relative share of various American academies is concerned, this study is of no particular interest outside the United States; but a number of facts of more general interest emerge from the study. Thus we learn that more than three-fourths of the starred scientists have been employed by universities in recent years; also most starred scientists, for reasons that may well be in dispute, belong to the so-called upper classes, the highest percentage (one in seven) being fathered by Unitarian clergymen, the lowest (one in 196) by engineers. Cities are more likely to produce notable scientists than rural areas.

The statistical results given as to academic careers, however, must be considered as limited in their value when one finds among the starred physicists without a degree such a name as that of Einstein; he presumably appears in this category as having no American degree. The best chance of becoming a starred scientist seems to lie with those born in March, with January, May and October some way behind. A study of the lists in the various subjects shows no obvious omissions; but on the whole a tendency to go slightly below the level which would probably be aimed at in a similar classification in Britain. The book provides a mine of information about American men of science as a whole, which may well interest the curious as well as the serious student.

Children as Naturalists

By Margaret M. Hutchinson. Pp. 184 + 9 plates. (London: George Allen and Unwin, Ltd., 1947.) 7*s*. 6*d*. net.

MARGARET HUTCHINSON is the granddaughter of the late Sir Jonathan Hutchinson, who founded the Educational Museum at Haslemere. In 1931 she opened her own junior school at her parents' home, Yafflesmead, near Haslemere. The school flourishes amid acres of semi-wild garden, meadow and woodland, and in this setting an enthusiast has shown how children's interest in Nature may be fostered through exploration, discovery and intimate contact with living creatures.

"Children as Naturalists" is a record of Miss Hutchinson's work and a testimony to her enthusiasm. Three general chapters on "Exploring with the Kindergarten", "Adventures with the Sixes and Sevens" and the "Study of Environment with Juniors" are followed by seven others called "The Quest for . . .", mammals, birds, pond creatures, flowers, etc. There are some useful photographs and diagrams to illustrate the text and many practical hints about the making of apparatus, as well as some of the scientific information needed by the teacher but not easily found in elementary text-books.

All this will be useful to the junior school teacher; but Miss Hutchinson's obvious advantages—small classes, large and varied grounds and the fact that she herself is a scientifically trained and passionately enthusiastic naturalist—should make her sympathetic with all teachers of Nature study in junior schools who do not reach the high standards revealed in this little book. T. H. HAWKINS

New Biology, 3

Edited by M. L. Johnson and Michael Abercrombie. Pp. 176 + 24 plates. (Harmondsworth: Penguin Books, Ltd., 1947.) 1*s*.

THE third volume of "New Biology" maintains the standard of its predecessors. Addressed primarily to those who have a taste for scientific reading, this miscellany of essays aims at giving an up-to-date account of some aspect of biology which has excited contemporary interest. Contributions like "The Electron Microscope" and "Biological Research" by V. E. Cosslett are likely to be tough going for readers who know little about biology; but Alec Parker's article on "Beasts of Burden" will be as fascinating to the schoolboy as the *savant*. Articles on "How a Grasshopper becomes a Locust", "Forage Plants", "The Menace of the Roundworm", "Animal Life in Caves" and "Biology of Ship Fouling" indicate that the joint editors are well aware of those subjects which make popular reading.

The Genetics of Garden Plants

By M. B. Crane and W. J. B. Lawrence. Third edition. Pp. xvii + 299. (London: Macmillan and Co., Ltd., 1947.) 16*s*. net.

"CRANE and Lawrence" is now a standard text for both students of biology and for practical gardeners. Indeed, it is one of the few books which fulfil a want both for the academic specialist and for the practical man. The third edition is different in some respects from the earlier editions; parts of some chapters have been rewritten, and the subjects of xenia and polyploidy receive greater attention in special chapters. One criticism of the earlier editions was that the elementary introduction to genetics was too condensed for the non-specialist. By some clever and subtle writing the authors appear to have largely overcome this criticism in the third edition. Through fully annotated descriptions of research results, the book is an invaluable guide to the recent literature on horticultural plant genetics. F. W. SANSOME

Territory in Bird Life

By Eliot Howard. New edition. Pp. 224 + 11 plates. (London and Glasgow: Wm. Collins, Sons, and Co., Ltd., 1948.) 10*s*. 6*d*. net.

A FRESH edition of Eliot Howard's classic book on "Territory in Bird Life" is indeed welcome, for it has long been difficult to obtain a copy of a work that every ornithologist should read. Published in 1920, it put forward the theory, supported by the author's many and painstaking observations, that the chief pivot of bird-life was territorial, nearly all birds needing to secure and hold a territory as a basis of their sexual activity and breeding cycle. This seemingly simple theory was found to have far-reaching implications, and to throw light on many aspects of bird behaviour; indeed, its importance has become more and more apparent with the passing of the years. It is good to have this new edition of so important a book. FRANCES PITT

STUDIES OF THE STRUCTURE OF SYNTHETIC POLYPEPTIDES

By Prof. W. T. ASTBURY, F.R.S.
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Dr. CHARLES E. DALGLIESH
University Chemical Laboratory, Cambridge

AND

S. E. DARMON and Dr. G. B. B. M. SUTHERLAND
Department of Colloid Science, University of Cambridge

THE recent synthesis of polypeptides from given amino-acids by Woodward and Schramm[1], following the neglected Leuchs polymerization[2], has reopened a promising line of attack on the problem of protein structure. Comparison of the properties of such synthetic polypeptides of known composition with those of proteins built of the same amino-acids should prove of great value, and in particular should help considerably in the interpretation of X-ray and infra-red data, which are still so imperfectly understood owing to the complexity of even the simplest protein. The general object of the work of which the preliminary findings are summarized below is therefore to synthesize as many as possible, first of homogeneous polypeptides (that is, those containing a single amino-acid species) and secondly of copolymers of two or more amino-acids, and then, by X-ray, infra-red and accessory techniques, to study their properties in relation to those of proteins of analogous composition.

Chemical

The polymerization of the anhydrocarboxyamino-acids was in the early cases performed in ethyl acetate in the presence of a tertiary base. Though this method has the disadvantage of giving unoriented products as white amorphous powders (the molecular weights being probably of the order of 2,000–5,000), it has the advantage that yields of the order of 50–70 per cent of polypeptide can be obtained from amino-acids available in quantities of only $\frac{1}{2}$–1 gm.

With increasing availability of amino-acids, polymerizations have been carried out by the Woodward procedure, which permits in suitable cases the preparation of oriented products. The following amino-acids have been polymerized so far: glycine, sarcosine, *DL*-alanine, *L*-alanine, *L*-valine, *DL*-leucine, *D*-leucine, *L*-leucine, *DL-iso*leucine, *D-iso*leucine, *L-iso*leucine, *DL-nor*leucine, *DL*-α-phenylglycine, *DL*-phenylalanine, *L*-phenylalanine and *L*-tyrosine. Difficulty has been experienced with proline by this procedure, and this and other amino-acids are under investigation.

Marked differences have been observed between polymers from *DL*- and from optically active amino-acids, a particularly striking case being alanine, where poly-*DL*-alanine is readily soluble in water whereas poly-*L*-alanine is insoluble. In some cases the products separate with what appears to be half a molecule of structural water per amino-acid residue, which is much less readily removed from the polypeptides derived from optically active amino-acids than from those derived from *DL*-mixtures. The various mixed polypeptides have been synthesized by both the above procedures.

X-Rays

It is convenient to consider the kinds of X-ray diagrams obtained so far under the following heads:

(*a*) *Polyglycine.* So long ago as 1934, Meyer and Go[3] reported on an X-ray examination of glycine polypeptides obtained by the Leuchs reaction. Their photographs were not analysed in detail, but they drew the conclusion that the atoms in the product formed when the N-carboxylic anhydride is exposed to moist air lie for the most part in planes of spacing 4·15 A. They mention, however, but do not reproduce, another kind of diagram characterized by reflexions at 4·4 A. and 3·45 A., that is obtained when the reaction is carried out in the presence of pyridine. Our diagram (Fig. 1*a*) is apparently like this latter, though we have also found indications of the former in X-ray photographs of wool fibres, supplied by Prof. J. B. Speakman, on which a thin layer of polyglycine had been deposited by the Leuchs reaction carried out in ethyl acetate and water[4].

Fig. 1*a* is really a β-diagram made unfamiliar by having the backbone reflexion inside the side-chain reflexion. It is consistent with a rectangular or near rectangular cell defined by $a = 4{\cdot}36$ A. (or $2 \times 4{\cdot}36$ A.), $b = \sim 7$ A., and $c = 3{\cdot}44$ A. The structure appears to be analogous to that worked out by Bunn and Garner[5] for the so-called 6.6 and 6.10 nylons, and it is built presumably of sheets of chains parallel to (001). The chains in each sheet are linked by CO ... NH linkages and their distance apart is 4·36 A. (cf. 4·4 A. in nylon and 4·65 A. in β-keratin).

(*b*) *Powder diagrams of the normal* β*-keratin type.* One of the best-defined of these was obtained from a powder of poly-*DL-iso*leucine (Fig. 1*b*); but diagrams of a similar type were given also by the polymers of *D*- and *L-iso*leucine, *DL*-alanine, *DL*-α-phenylglycine, *DL*-phenylalanine and *DL-nor*leucine, and by the copolymers (glycine + *DL*-alanine), (glycine + *DL*-phenylalanine), and (*DL-iso*leucine + *DL*-phenylalanine). As with disoriented β-keratin, β-myosin, etc., and denatured proteins, the principal rings are 001 (side-chain), 200 (backbone) and 210. The side-chain spacing increases with length of side-chain, as would be expected; but it is seen also that the backbone spacing shows significant variations: for example, glycine 4·36 A., *DL*-alanine 4·59 A., *DL-nor*leucine 4·60 A., *DL-iso*leucine and *DL*-phenylalanine 4·65 A., *D*- and *L-iso*leucine and *DL*-α-phenylglycine 4·72 A. As reported in the following section, corresponding variations are *not* found in the infra-red spectra, which indicate that the CO ... NH hydrogen bond is similar in all the polymers.

These combined observations are of the highest importance, showing as they do that in spite of irregularities in chain direction caused by long or ungainly side-chains, with consequent variations in the backbone spacing between chains *as a whole*, the CO- and NH-groups of adjacent chains approach each other always to nearly the same distance. In the same connexion it should be mentioned that there are indications from other spacings that the effective length per residue in polyglycine and poly-*DL*-alanine may be a little greater than the maximum ($3\frac{1}{2}$ A. in silk fibroin) observed in the fibrous proteins, and this recalls Corey's estimate[6] from X-ray crystal data on glycine, alanine and diketopiperazine that the effective length per residue in a *completely* extended polypeptide chain should be 3·67 A.

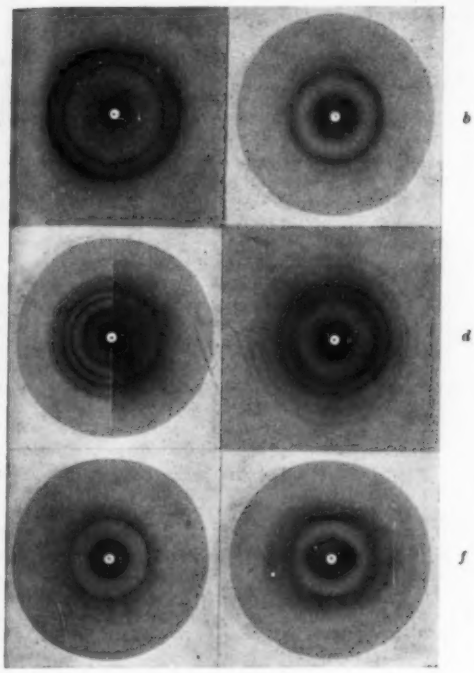
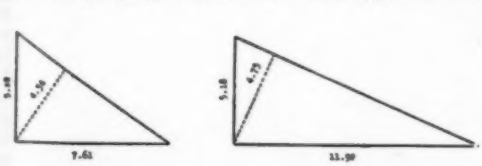


Fig. 1. (*a*) Polyglycine; (*b*), poly-*DL*-*iso*leucine; (*c*) comparison of poly-*DL*-alanine (right) with poly-*L*-alanine (left); (*d*) poly-*L*-phenylalanine; (*e*) poly-*D*-leucine + *DL*-phenylalanine, X-ray beam perpendicular to film; (*f*) poly-*D*-leucine + *DL*-phenylalanine, X-ray beam parallel to film

The powder diagram of the copolymer (*DL*-*iso*leucine + *DL*-phenylalanine) shows a strong side-chain reflexion of similar spacing to those of the polymers of the separate constituents; it is noteworthy, however, that no definite side-chain reflexion, but only a haziness, is seen in the diagrams given by (glycine + *DL*-alanine) and (glycine + *DL*-phenylalanine).

(*c*) *Abnormal powder diagrams.* Some of the powder diagrams discussed under (*b*) show unfamiliar features not yet fully accounted for; but on the whole it seems correct at the moment to regard them all as belonging to the type of β-keratin, that is, as structures built up by superposing flat or almost flat polypeptide grids so that the general directions of the side-chain and backbone linkages stand perpendicular, or almost perpendicular, to each other. All these normal β-diagrams, except those from poly-*D*- and poly-*L*-*iso*leucine, were obtained from *DL*-polymers and copolymers. A number of products, however, from *D*- or *L*-acids alone have been found to give diagrams showing a systematic peculiarity: there is notably a reflexion at about 5·2 A., and to explain the accompanying reflexions it would appear that it



(*a*) (*b*)

Fig. 2. (*a*) Poly-*L*-alanine; (*b*) poly-*L*-phenylalanine

is this spacing, and not the normal backbone spacing, that has now to be taken perpendicular to the side-chain spacing. The counterpart of the normal backbone reflexion is present, too, but its spacing is now 'diagonal' (see Fig. 2); so that what was 200 in the *DL*-diagram becomes 201 in the *D*- or *L*-diagram, while the normal 210 becomes 211 (see Fig. 1*c* for a comparison of the diagrams of poly-*DL*- and poly-*L*-alanine, and note that the strong reflexion at 5·28 A. in the latter is completely absent from the former).

This kind of modification has so far been observed with the polymers of *L*-alanine, *L*-valine, *L*-phenylalanine, and probably *L*-tyrosine; and poly-*DL*-leucine shows it with an additional complication that we have not yet elucidated. The diagram given by poly-*L*-phenylalanine (Fig. 1*d*), consisting of at least fifteen clear reflexions, is particularly striking: most or all of the reflexions can be explained on the basis of a rectangular cell of dimensions: $a = 2 \times 5{\cdot}18$ A., $b = 2 \times 3{\cdot}33$ A. (presumed amino-acid spacing), and $c = 11{\cdot}92$ A. (side-chain spacing).

The interpretation of these homogeneous polymers of *D*- or *L*-acids alone thus seems to require a new kind of side linkage in place of the backbone linkage met with hitherto. The new spacing is greater than the usual backbone spacing, and a possible explanation would be that it incorporates perhaps a water molecule between CO- and NH-groups of adjacent main chains, which are apparently still in the extended configuration.

(*d*) *Films.* For the present we are able to report only limited progress in making films or other oriented preparations of synthetic polypeptides. Traces of orientation could be detected in a pseudo-film of poly-*D*-leucine, and quite a rich, partially oriented diagram was obtained from a very brittle film of poly-*L*-tyrosine. This latter diagram has not yet been worked out satisfactorily.

The outstanding single set of results with films comes from preparations of the copolymer (*D*-leucine + *DL*-phenylalanine). It was first reported by Brown, Coleman and Farthing[7] that films of this copolymer, prepared by the method of Woodward and Schramm, gave, when photographed with the X-ray beam parallel to the surface, a quasi-fibre diagram resembling the well-known α-diagram given by the unstretched forms of the keratin-myosin-epidermis-fibrinogen group of fibrous proteins[8]. We have confirmed this finding (with films deposited on glass) and have made some further advances. Two of our photographs are illustrated in Figs. 1*e* and 1*f*, the former taken with the beam perpendicular to the film and the latter parallel. The film used for Fig. 1*f* was obtained from the inside of a glass tube in which a benzene solution of the copolymer (ratio 1 : 1) had been evaporated at about 70° C.: the orientation is the best so far produced in a film.

The following points may be noted. (1) The spacing of the prominent meridional arc, which so strongly recalls that of the α-diagram, is $5{\cdot}2_3$ A., and not $5{\cdot}1_4$ A. as found in α-keratin. (2) The intense central oval in Fig. 1*f* is foreign to the α-diagram: on the meridian its spacing is 11·9 A. (practically identical with the presumed side-chain spacings found in the powder diagrams of poly-*L*-phenylalanine and poly-*DL*-leucine), and on the equator $10{\cdot}3_7$ A. There is also a weak meridional reflexion at 7·4 A. (3) The central oval in Fig. 1*f* becomes a circle of spacing 11·9 A. in Fig. 1*e*: the $10{\cdot}3_7$ A. spacing is therefore preferentially oriented perpendicular to the film.

Pending the outcome of experiments, which are in progress, to prepare genuine fibres, it would be premature just now to attempt any detailed interpretation of this most interesting diagram. None of the usual methods of transforming α- into β-proteins has yet proved effective in changing it into one of the orthodox β-type, and in view of the diffraction peculiarities mentioned it is very questionable indeed whether it is a case of a true α-structure: rather does it recall the polymers of *D*- and *L*-acids described under (*c*), which appear to be in the extended configuration, but with a new kind of side-linkage of spacing of about 5·2 A. Incidentally, the 1 : 1 ratio of the constituents of the copolymer is not specific, since we have obtained a powder diagram of a similar type with the ratio 5 : 3.

(*e*) The investigation is being continued along the lines of further combinations of amino-acids and preparations oriented if possible as fibres. Exact knowledge is also being sought on the extent to which some of these synthetic polypeptides may combine with water, and the bearing this may have on the occurrence or not of the supposed new side-linkage of spacing about 5·2 A. If it should turn out that such a type of spacing includes also that found in the film diagram given by the copolymer (*D*-leucine + *DL*-phenylalanine), it is nevertheless still on the cards that it may lead to a proper understanding of the characteristic meridional arc in the true α-diagram; for it is to be remembered that the postulated α-fold may be thought of as stabilized by what amount to *side*-linkages—not simply between adjacent main chains, of course, but between short consecutive lengths of one and the same main chain[9].

We are also investigating possible cases of polymorphism among the products obtained from base-catalysed and uncatalysed polymerizations.

The X-ray photographs discussed above were taken by Mr. E. Beighton, to whom we should like to express our thanks.

Infra-Red

The general resemblance between the near infra-red spectrum (between 3,500 and 1,500 cm.$^{-1}$) of a synthetic polypeptide and that of any protein molecule has already been remarked[10]. This arises from the fact that the main absorption bands in this region of the spectrum are due to characteristic vibrations in the —CO—NH— group and to CH-stretching frequencies. As we proceed farther into the infra-red (that is, to the lower frequencies between 1,500 and 700 cm.$^{-1}$), many of the absorption bands are due to characteristic vibrations of the hydrocarbon side-chains of the various amino-acids. It was suggested[10] that differences in this region of the spectrum might be made the basis of a method of identifying an amino-acid residue in a protein, provided sufficient data were available on the spectra of polypeptides synthesized from various amino-acids. We have accordingly examined the spectra of a representative selection of synthetic polypeptides from various amino-acids. However, we have not confined our attention to the region of low frequencies but have also studied the high frequencies of the —CO—NH— group, since it is here that variations in the hydrogen bonding which plays such an important part in the structure of proteins may be most readily followed.

(*a*) *Low-frequency region*, 1,500–700 *cm.*$^{-1}$. The spectra of powders of the polymers of glycine, *L*-alanine, *DL*-alanine, *L*-phenylalanine, *DL*-phenylalanine, *L*-leucine, *DL*-leucine, *L-iso*leucine, *DL-iso*leucine, *DL*-phenylglycine and *L*-tyrosine are all different from one another and quite characteristic in the region 1,500–700 cm.$^{-1}$. The differences between the spectra of polymers made from *D*- or *L*-forms of any acid and the spectra of the corresponding *DL*-forms are small compared with the differences between the spectra of polymers of different amino-acids, but are none the less quite real. We may therefore take it as established that each amino-acid polymer has characteristic frequencies, and the next question is whether these persist in copolymers made from two or more different amino-acids.

The answer to this is not quite so clean-cut and is less certain in that the number of copolymers so far studied is small. The spectrum of a (glycine + *DL*-alanine) copolymer was found to correspond remarkably closely to the 'addition spectrum' of the individual polymers, showing that there are certain bands which are characteristic for each amino-acid even when copolymerized. The spectrum of a (glycine + *DL*-phenylalanine) copolymer was also found to resemble closely the corresponding 'addition spectrum', certain bands of the individual polymers being clearly distinguishable, although a few of the others either disappeared or shifted in position in the copolymer. In this case, these differences were used to follow the progress of the copolymerization, samples of the copolymer being withdrawn for spectroscopic analysis at various stages. The copolymer (*D*-leucine + *DL*-phenylalanine) was examined both as a film and as a powder. The two spectra were virtually identical, and again many of the bands of the separate polymers were easily recognizable in the copolymer. There were, however, certain marked differences, and in particular this copolymer had a fairly strong band at 795 cm.$^{-1}$ which was not present (at least in comparable intensity) in either of the individual polymer spectra.

The conclusion to be drawn from these results is that for each amino-acid there are certain frequencies which persist in copolymers and may therefore be expected to persist in proteins containing these amino-acids. Such frequencies must clearly be due to the hydrocarbon chain in the amino-acid, and in a few cases assignments (based on the interpretation of hydrocarbon spectra) have been possible, although these need not be discussed here. Certain other

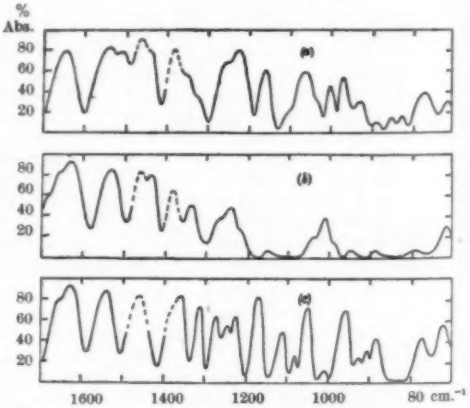


Fig. 3. Infra-red absorption spectra in the region 1,700–700 cm.$^{-1}$ of: (*a*) Silk fibroin (fibres immersed in nujol); (*b*) polyglycine; (*c*) poly-*L*-alanine (powders suspended in nujol). Broken lines indicate absorption due to nujol

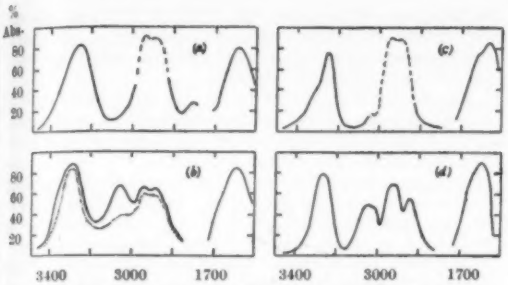


Fig. 4. Infra-red absorption spectra in the regions 3,500–2,800 cm.$^{-1}$ and 1,700–1,600 cm.$^{-1}$ of: (*a*) silk fibroin (fibres immersed in nujol); (*b*) tropomyosin film (—— film prepared at room temperature, ... after pressing in steam); (*c*) poly-*L*-alanine (powder suspended in nujol); (*d*) film of *D*-leucine + *DL*-phenylalanine copolymer (ratio 1 : 1).

Broken lines in (*a*) and (*c*) indicate absorption due to nujol

frequencies in this range appear in the simple polymer spectra but not in the copolymers and *vice versa*. The assignment of these is not yet clear, but they most probably arise from vibrations associated with the bonds involved in the link between the side-chains and the backbone.

We have successfully applied the above results to the identification of amino-acids in a protein, and believe that this is the first occasion on which this has been done without decomposing the protein molecule. In Fig. 3 are given the spectra of silk fibroin together with those of polyglycine and poly-*L*-alanine. The appearance of certain of the bands in the synthetic polypeptides in the natural protein is so obvious that it does not require detailed comment. It need scarcely be added that this method is unlikely to be successful except in very favourable circumstances for detecting amino-acids which are present in small proportions, although we might add that we believe that we have also identified tyrosine in silk fibroin. The amino-acid analysis of a complex protein by this method is, of course, quite impracticable. What we consider much more important is that further investigations along these lines with copolymers of controlled structure and composition may throw light on the arrangement of the amino-acids in some of the simpler proteins.

(*b*) *High-frequency region, 3,500–1,500 cm.*$^{-1}$. The NH- and CO-stretching frequencies near 3,260 cm.$^{-1}$ and 1,640 cm.$^{-1}$, respectively, are essentially the same in all the polymer and copolymer spectra, whether from *DL*-, or *D*-, or *L*-acids. This means that the CO . . . NH hydrogen bond must be similar in all the polymers. At first sight this seems to conflict with the X-ray evidence that the backbone spacing varies from 4·36 A. (in polyglycine) to 4·72 A. (in poly-*DL*-α-phenylglycine), since a variation of this magnitude in a distance controlled by the CO . . . NH-linkage would certainly lead to a large variation in the NH-stretching frequency. If the explanation of this apparent anomaly advanced in the preceding section be correct, it underlines an important distinction between the structural information provided by X-ray and infra-red methods in problems of this kind, the former giving a diffuse overall picture of the structure from which hydrogen bond distances are deduced, whereas the latter gives a direct measurement of the length of the hydrogen bond but no direct information on the structural pattern unless polarized radiation is used on highly oriented films.

Although the CO- and NH-bands are similar in all the polymers, there are indications in many cases of some fine structure on the high-frequency side of each band. This has not yet been fully investigated, but it must mean that in many polymers *slightly* weaker hydrogen bonds exist in addition to the usual CO . . . NH-bond associated with the backbone linkage. This might arise from distortion of the backbone spacing in accommodating the side-chains, and may even be connected with the fact that films of certain polymers are harder to produce than others. Alternatively, it may indicate another type of hydrogen bond arising from some other feature of the structure yet to be elucidated.

That more than one type of hydrogen bond can exist in these polymers and in proteins is clearly demonstrated by the occasional occurrence of an NH-stretching band near 3,040 cm.$^{-1}$. This band is very prominent in the spectrum of the copolymer film (*D*-leucine + *DL*-phenylalanine), but is either absent or comparatively weak in the spectra of all the other polymers (Fig. 4). The fact that the X-ray evidence at first sight indicated an α-configuration for this copolymer seemed to be consistent with the fact that this 3,040 cm.$^{-1}$ band is present in the spectrum of the α-form of tropomyosin but weakens very markedly when the tropomyosin is converted to the β-form by pressing between plates in steam[11]. Moreover, we find this band is absent in the spectrum of silk fibroin known to have a β-configuration (Fig. 4). However, what seemed a striking correlation between the presence or absence of this band and the existence of α- or β-configurations breaks down completely when one considers the spectrum of nylon. This band is present in nylon, which has been shown by Bunn and Garner[5] to have a β-configuration. All we can say at present, then, is that there are at least two very distinct types of hydrogen bonding present in many proteins and in some protein-like polymers (notably nylon and *D*-leucine + *DL*-phenylalanine), and that this bond appears to be connected in some way with folding of the polypeptide chain.

In this connexion two minor but important points should be mentioned. The first is that there is no doubt whatever that the 3,040 cm.$^{-1}$ band is due to an NH-frequency, the most direct proof being that we find it is absent in the spectrum of fully methylated nylon. Incidentally, we have investigated this very interesting band extensively in simpler amides, but a full account of this work must be given elsewhere. The second point is that it is just possible that the weakening of the 3,040 cm.$^{-1}$ band observed by pressing tropomyosin between plates in steam may arise from a known orientation effect[11]. This is being investigated further by using polarized radiation.

In the preceding section on X-ray diffraction it was noted that marked differences occurred in many cases between the patterns given by *D*- or *L*-polymers and those given by *DL*-polymers. Little or no correlation has so far been found between these results and the infra-red spectra of the corresponding compounds. In particular, no clear evidence of water molecules in the *D*- or *L*-polymers has yet been found. Although the weak band on the side of the main NH-band at 3,240 cm.$^{-1}$, in poly-*L*-alanine might possibly be due to water, this extra band was not found in poly-*L*-phenylalanine.

The final elucidation of many of the above results cannot be given until much more experimental work has been carried out, particularly on oriented films with polarized radiation.

We are very much indebted to Dr. K. Bailey for the specimen of tropomyosin, and to Dr. G. R. Tristram for the specimen of silk fibroin.

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COLOUR AND COLOUR VISION IN ANIMALS

ON September 13, a series of papers on colour and colour vision in animals was read before Section D (Zoology) of the British Association. The object of the discussion was to consider recent results on the physiology of colour production and appreciation in animals, and the bearings of these results on theories of the biological uses of colour—in protective resemblance, mimicry, warning coloration and other ways.

The discussion was opened by Dr. R. J. Pumphrey with a paper on the distribution of colour perception in the animal kingdom. He first pointed out the difficulties in the way of obtaining experimental proof of the presence of colour discrimination in animals, which can tell us of their perceptions only by their behaviour. Besides this, colour is itself a difficult experimental subject; it is never easy to exclude other stimuli such as those of variations in brightness—to the animal and not to us—and, if the animal's spectral range differs from ours, control of wave-lengths outside our visible range is needed. Further, the animal's behaviour will be influenced only if perception of the colour is important to it; and changes of behaviour can be interpreted only if the animal behaves in a consistent and intelligible manner, and is not disturbed by other stimuli or by its own nervous state.

Nevertheless, colour perception has been established beyond reasonable doubt in some insects and, among vertebrates, in some bony fishes, reptiles, birds and the primates. Dr. Pumphrey believes its presence in the Crustacea and Cephalopoda unproved. In the rest of the animal kingdom there is no sound evidence of its presence, and in many groups failure to demonstrate it makes its presence unlikely.

Animal colour perception, where it exists, resembles our own rather closely. There is no evidence of dichromatism as a primitive condition; but this may be due to inadequate experimental methods. Some birds and fishes may have a closed colour circle, that is, they may fail to distinguish red from violet, and may not recognize extra-spectral purples. Many insects see much farther into the ultra-violet than we do, and can distinguish ultra-violet from the parts of the spectrum visible to us. Insects see colours in weak light so long as they are able to see at all; in this they are in contrast with vertebrates, whose perception of colour fails in weak light. At night vertebrates have no colour sense; all nocturnal vertebrates are colour-blind.

Dr. R. W. Pickford spoke on the varieties of colour vision in man. Total colour-blindness is rare. The most usual abnormalities are deuteranopia, in which red and green are confused, looking yellowish, and protanopia, in which there is also a great darkening of the red end of the spectrum. In anomalous colour vision, discrimination of colours is retained; but either red or green may be greatly weakened as compared with the normal. With red anomalous vision there is in some cases also darkening of the red end of the spectrum. All are Mendelian recessives and sex-linked, except that in total colour-blindness the linkage is partial. About 7 per cent of men show red-green colour-blindness.

In addition to these major defects, minor variations from normality occur. The commonest is a weakness of blue discrimination; those with it tend to confuse greenish-blues, such as Cambridge blue, with green. Yellow weakness also occurs, and leads to confusion of yellow with white. These minor defects are not sex-linked.

Dr. M. G. M. Pryor discussed the conditions under which colour in an animal can be certainly said to be adaptive. Adaptiveness implies that the colour has selective value and that in the absence of selection the colour would be different from what it now is. To prove adaptiveness, we therefore need to know the natural non-adaptive colour. Often this is white, as in many cave animals that live in the dark, but not always so. Some cave insects are black or brown, the colour of the dark tannin with which their chitin is hardened. Dark colour in an insect therefore needs no 'adaptive' explanation. Whiteness in an insect is more unusual and is often due to a layer of unhardened—and undarkened—chitin outside the dark chitin within it.

Brilliant colours are not always adaptive. Golden colour, as in the pupa of the peacock butterfly, may be due to the natural colour of the chitin. Brilliant interference colours may be due to a number of thin, transparent films of chitin of the right thickness. Often these colours occur where they cannot be adaptive—inside the cast skins of bluebottle pupæ, or in the bristles of the sea-mouse which lives buried in mud. The blues and greens of the outer surface of bluebottles and dung-flies are due to interference at the layer of wax that covers the chitin.

Some of these colours may have been exaggerated or otherwise modified adaptively, but a knowledge of what the colours would be without adaptation and of the manner in which they are produced is necessary if we are to assess the adaptive element in them.

Dr. G. S. Carter discussed, in the light of the facts given by the previous speakers, the conditions under which colour as seen by other animals may be of importance in the biology of an animal. First, it is clear that not all animal colour has this importance. To the categories of non-significant colour already mentioned may be added much colour in lower invertebrates, such as many sea-anemones and sea-urchins, which have few enemies. This is at least true of the many species that do not catch large animals as prey. Much colour in physiological substances is non-significant—blood pigments, excretory substances. Some pigment may be used as defence against light, as probably the black pigment of many

desert animals, but is not related to the animal's contacts with other animals.

Value in colour in the biological environment implies that the animal seeing it has colour vision. As Dr. Pumphrey showed, only some arthropods and some vertebrates have been shown experimentally to have this faculty. Perhaps some cephalopods should be added, on the evidence of their natural behaviour and not on experimental results. Such evidence may be as conclusive as the experimental.

Wherever colour is of value in the interactions of animals, except in the rare cases where the stimulus is a simple flash of colour, pattern appreciation as well as colour perception is necessary in the observing animal. It is therefore not surprising that a colour sense and an image-forming eye are associated in animals, for pattern appreciation is the characteristic of image-forming eyes.

In recognition of an animal by another, two distinct components of the process of recognition must be distinguished. First, the animal must be recognized as a discrete object on its background. This is prevented by the various forms of camouflage. Secondly, the animal must be recognized as of a particular kind—for example, of a kind suitable as food. To understand how the second can be prevented by adaptation in colour and pattern, we need to know how animals recognize the kinds of objects.

In much of their behaviour, animals, even such complex animals as birds and insects, recognize the kinds of objects not by an aggregate of many characters, as we do, but by one, or at most a few, 'valent' characters, such as the smell, shape, colour, pattern or type of movement. Not all animal behaviour is of this simple type; but so far as it is, a resemblance that includes the valent characters will be effective, although in other characters there is no resemblance. But if an animal is exposed to predators of many species, a detailed and complicated resemblance may be built up by combining the different valent characters required by the various species. We can thus see how the astonishingly accurate resemblances we find in Nature may have originated from very partial resemblances which, in spite of their incompleteness, would still have had some value. G. S. CARTER

PHYSIOLOGY OF LACTATION

AT a joint meeting of Sections M (Agriculture) and I (Physiology) of the British Association, held at Brighton on September 14, recent research on the physiology of lactation was discussed. Prof. H. Hartridge, president of Section I, was in the chair.

The discussion was introduced by Prof. H. D. Kay (National Institute for Research in Dairying, Shinfield) who said that in view of the importance of lactation both from the human and from the industrial points of view, it is remarkable that the physiology of the mammary gland had, until recent years, received so little attention. During the past dozen years, however, knowledge has advanced substantially as regards the endocrine control of mammary development and of milk secretion, including the artificial induction of lactation in the virgin or barren animal, the hormonal inhibition of lactation, the cytology of the gland in relation to function and the 'let-down' of milk as a conditioned neuro-hormonal reflex. The biochemistry of milk secretion, including both glandular metabolism and the factors affecting milk composition, have also undergone active study. Advances in knowledge of the neuro-hormonal mechanisms by which the mammary gland is controlled are already beginning to influence both milking technique and also clinical methods of dealing with problems of human lactation.

There is a very rapid blood-flow through the actively secreting gland, and a large consumption of oxygen. The respiratory quotient of the secreting tissue is, in the intact animal, well above unity, and in surviving slices of tissue suspended in a nutrient solution, figures as high as 1·5–1·6 have been obtained by T. H. French, suggesting fat formation from carbohydrate. A major difficulty in recent biochemical studies in the intact animal is the uncertainty of the extent of error due to lymph drainage, and all findings depending on arterio-venous changes must be interpreted very cautiously.

The practical significance was pointed out of the recent work of Dodd and Foot at Shinfield, who have found that more than 50 per cent of the fat originally present in the secreted milk in the bovine udder is *not* removed during the ordinary process of milking. Very recent findings which indicated that milk composition might be influenced by naturally occurring œstrogens present in young grass and clover were also described. The relationship between the texture of the teat and liability to udder infection, established in the last few months by J. I. Taylor at Compton, was mentioned as a new factor that seems of importance in buying or breeding a cow.

Mr. K. C. Richardson (University College, London) described with the aid of slides some of the results of his recent studies of the cytology of the mammary gland in relation to function. The milk-secreting alveoli are not usually spherical, but are rather elongated structures, the secreting cells of which show great changes in shape and size at different stages in the secretory cycle. The synthesized milk constituents pass from these cells into the alveolar lumen by recurrent rupture of the cell membrane. Whether or not there are nerve fibres ending in the secretory tissue is as yet unsettled, the available histological technique being insufficiently specific. He discussed the possible mechanism of 'let-down'. There is no doubt that during 'let-down' active pressure is brought to bear on the milk which has been secreted into the alveoli. Smooth muscle, though present in the mammary gland, is neither in the right places nor in sufficient quantity to make any serious contribution to the 'let-down' phenomenon. There are no sphincters on the ducts emerging from the lobules. However, as a result of a recent advance in histological technique, clear evidence has been obtained of the abundant presence in the gland of myo-epithelial cells, the large nuclei of which are usually to be found between the alveolar secreting cells and the basement membrane, and the processes of which can be shown to extend over the outer surface of each alveolus. Convincing histological evidence was brought forward by Mr. Richardson that these cells can and do contract at 'let-down'; the basket structure, tightly embracing the distended alveolus before 'let-down', does not become flaccid when the milk has been forced out and the alveolus diminished in size, but remains taut.

Dr. S. J. Folley (National Institute for Research in Dairying, Shinfield) briefly mentioned three stages

in the history of research on the control of the mammary gland. In the earliest stage, the control appeared to be mainly of neural origin; but the establisl ment of the fact that mammary tissue could actively secrete when removed from any nerve connexion with the rest of the body, together with experiments showing the great importance of hormonal influences on the gland, led for a time to mammary physiology becoming almost a branch of endocrinology. The more balanced, modern view that neural and hormonal influences must be considered together in obtaining a satisfactory picture of the growth and function of this gland is now supported by increasing evidence. Thus the sucking stimulus apparently causes reflex secretion of prolactin by the anterior pituitary, by a pathway not yet understood, and is of importance not only in initiating milk secretion but also in maintaining it and in indirectly preserving the structural integrity of the milk-producing tissue.

The milk already secreted by the gland is, before suckling or cowshed milking, present in two portions. One can be obtained from the gland cisterns in the cow by careful cannulation (avoiding nervous stimulation); the other portion of the milk is more tenaciously held in the smaller ducts and capillaries and has to be forced out by an active (but involuntary) process. This latter process, 'let-down', though activated by a posterior-pituitary hormone, is in the intact animal a nervous reflex that can become conditioned, and is easily inhibited, both in the bovine and in the human. In the denervated udder, or in the isolated, perfused gland, 'let-down' can, however, be readily brought about by the introduction of oxytocin into the circulating blood. There is no evidence for the 'erection' of udder tissue by engorgement with blood; the true nature of the contractile tissue in the gland, hitherto uncertain, has now been established for the first time by the experiments just described by Mr. Richardson.

Dr. K. L. Blaxter (Hannah Dairy Research Institute, Ayr) described recent applications to dairy cattle of hormonal treatment for initiating or increasing milk secretion. Widespread treatment of thousands of normal animals presupposes a large supply of endocrine preparations, and for this reason synthetic sources of hormones are of the greatest potential use; synthetic œstrogens and iodinated proteins containing thyroxine can now be made on a large scale.

Lactation in barren cows and virgin heifers can be induced in a large proportion of such animals, though not, apparently, in all, by administration of synthetic œstrogens of the stilbœstrol type. There is great individual variability in the quantitative response to such treatment, for reasons that are not yet clear. Another practical handicap is that the treated animals are 'on heat' during the whole period during which the œstrogen is being administered; this leads, if the treated animals are allowed to run with other cows, to coital mimicry and the serious risk of pelvic fracture, since the œstrogen causes relaxation of the pelvic ligaments.

The feeding of iodinated proteins to lactating cows induces an increase in milk production, the magnitude of which depends on the dose given to the cows. A reasonable practical increase, say, of 20–25 per cent, can readily be obtained. Experiments were described showing the effect of such treatment on both milk-yield and composition and on the condition and behaviour of the animals. The milk obtained after feeding iodinated protein shows no thyroxine-like effect when taken in quite large quantities by human consumers, though its iodine content is increased. From the economic point of view, the value of the extra milk produced is considerably greater than the cost of the iodinated protein plus the extra feeding stuffs required. The margin of safety between an optimal dose and one which causes breakdown in the cow is not sufficiently large to allow the material to be used by other than competent farm staff. So far, in experiments lasting several months during which carefully controlled quantities were fed, there were no bad effects on the cow's health either at the time or in the next lactation; but until long-range experiments, now in progress, are completed, iodinated protein feeding cannot be regarded as a practical method for increasing the nation's milk supply.

Dr. Gaines (Glasgow) showed, by lantern and microscope, recent results of histological examination of human nipples. There are very abundant nerve endings in the nipple, many of them associated with smooth muscle cells, and associated with the erection that takes place after stimulus. The sucking stimulus of the infant is remarkable—the suction on the nipple could be as great as 100 or even 200 mm. of mercury. So far, though their presence had formerly been assumed in the nipple, no Meissner corpuscles had been found.

A discussion followed the papers referred to above.

PRIMITIVE TECHNIQUES, AGRICULTURE AND ECONOMIC ORGANISATION

PRIMITIVE techniques and their influence upon economic organisation was the subject of a discussion in Section H (Anthropology) of the British Association on September 10 at Brighton. Mr. R. U. Sayce, president of Section H, was in the chair.

The discussion was opened by Mr. Adrian Digby, who laid stress on the importance of the time factor. The study of society and the study of technology have, he said, been drifting apart under the influence of the functional school. The welter of closely integrated, not to say tangled, data with which social anthropologists have to deal has led those with leanings towards sociology to jettison the study of material culture as of least value to their particular interests and to specialize in social structure as a way out of their difficulties. On the other hand, those interested in material culture have paid more attention to the 'anatomy', as it were, than to the 'physiology' of their material. But there is a very close relation between social organisation and the manner in which people set about satisfying their needs in life.

There are, said Mr. Digby, six essential factors necessary to the daily life of any community: namely, (i) food, (ii) clothing, (iii) housing, (iv) fuel, (v) social integration for the distribution of the results of labour, and for security, and (vi) social integration for emotional and intellectual satisfaction. Under this latter head he included religion, marriage and relaxation. The relative importance of these six factors would vary according to circumstances, but the growth of any one in importance, or in time occupied, would be at the expense of some

other factor or factors of the six enumerated. This he illustrated by reference to the Australians, whose dependence on hunting and food-gathering, a slow method of producing food, leaves relatively little time for anything else except the elaborate rituals which satisfy the sixth need in their case and were also partially or largely directed to improving the food supply. With the Australians he contrasted the modern Maya, who, cultivating maize on the *milpa* system (analogous to the dry cultivation of rice), can with 190 days work in the year produce nearly twice as much maize on a ten-acre plot as a family of five needs for consumption, and have 175 days left for the other five basic needs. These figures, derived from Steggerda, represent an economy that relies upon steel tools; the ancient Maya relied upon stone ones. Their production would therefore be much less, but one could still assume that they produced sufficient food to give them, without surplus, a similar 175 days of leisure. With that they built themselves ample wooden dwelling-houses, developed textile and ceramic arts to a high degree, attained great intellectual achievement in mathematics and astronomy, and constructed elaborate ceremonial centres such as Copan and Tikal. The bulk of the population seem to have been peasant farmers; but the life occupation of each child was predetermined by a system of casting horoscopes—direction of labour by divine sanction which any bureaucratic government might envy to-day. If more time had been required for food production, all these other developments could not have occurred in the same degree; greater or less stress on any one of these would have had a major effect on their culture as a whole. No general rule can be deduced owing to lack of data from a quantitative point of view.

In the case of techniques other than agriculture, data are even scantier. Thus in West Africa men and women use different looms with entirely different technique of weaving; the differentiation is not based apparently on any physiological grounds; the reasons for it may be historical or psychological; but, without data as to time, labour and production, it is impossible to tell how these different methods of weaving fitted into the social and economic organisation of the people who practised them. New tools may create demands requiring a departure from traditional practice; new methods may involve changes, economic or social, which social or psychological considerations are unlikely to invalidate. Changes in material culture tend to be adopted far more rapidly than social changes; but the impact of Western civilization on the social side is none the less great for being exercised through material objects.

The corrective element to the unfortunate centrifugal tendencies of modern anthropology is to be found in the study of the time factor as applied to all productive techniques and the labour forces available. It was for the more careful study, by field workers, of technical processes, and especially of the time and labour required for them, that Mr. Digby particularly pleaded.

Mr. G. I. Jones followed Mr. Digby with a paper on the north-eastern tribes of south-east Nigeria, known to their neighbours as the Ndi Ogu Uku—the People of the Big Hoe. These tribes have a social and economic structure very different from their neighbours, and Mr. Jones suggested that this is primarily and mainly due to the use and development of their superior agricultural tool. The normal Ibo tribal structure lays emphasis on concentration and consolidation into compact, and therefore politically safe, communities subsisting on hoe cultivation, but using the normal small hoe at the end of a crook-shaped handle. The Ndi Ogu Uku, however, use a hoe with a blade of similar shape, but much larger and hafted into a heavy club-shaped handle. This implement makes it possible to extend yam plantations rapidly over a much larger area, thus shifting the basis of economic importance from labour to land. Other Ibo tribes also have a colonizing system; but, apparently owing to the slower rate of cultivating and to the concentration of populations, colonies once thrown off tend to become independent units, with their own separate communal life, at a distance from the parent community. In the case of the Big Hoe people, however, their rapidity of expansion in uncultivated land has led to the throwing out of colonies on a periphery of perhaps twenty miles or more without any break in family or political organisation, the younger members of a family retaining an interest in the parent village site and sending back colonists to replace elder members of their line in tribal councils and in family properties as places fall vacant. The peripheral communities of Big Hoe Ibo may be numerically weak in themselves, but the retention of close integration with their parent villages provides the reliance on numbers necessary to political security; while the use of the big hoe makes possible a rapid territorial expansion and a rapid increase in population and in organised political power. The Ibo communities therefore illustrate the very marked change in social and economic structures which can be brought about by a very minor change in material culture.

In the short discussion that followed Mr. Jones' paper, it was made clear that the use of the big hoe among the Ibo seemed to have developed gradually and was not attributed to any particular invention or to any given 'culture hero'; the other tribes using the traditional small hoe professed inability to use the big hoe, but this was due rather to the absence of the tradition than to any physical incapacity. Prof. Gordon Childe congratulated Mr. Digby on having illustrated the true function of functionalism in anthropology.

Prof. J. H. Hutton followed with a comparison between the cultivation of wet and dry rice in the Naga Hills of Assam. Food was clearly the most important of Mr. Digby's six basic needs, since without it the others would not arise; the available leisure, and the surplus food, after the needs of the community were assured, would vary, and their utilization would vary, and different patterns of society would be determined accordingly. The common physical affinities and common ecological background of the Naga Hills has made possible the elimination of many variables and therefore a valid comparison between the two contrasting economies. The hilly terrain had probably led to some sort of terracing even for dry crops; rice was later in time than millet and had possibly been first introduced as an irrigated crop purely, and used also as a dry crop afterwards. Terraced irrigation on the very steep hillsides involves very long-term commitments and a much greater initial effort than dry cultivation, and the occupation of permanent village sites is implicit. But the periodic labour is very much less than in dry cultivation, and much greater periods of leisure are made possible as well as a generally greater economic surplus. Only when very long-standing forest is felled for dry rice is the yield greater than

from irrigated fields, and even then the labour of felling is greatly enhanced and leisure correspondingly restricted.

Prof. Hutton illustrated the point by describing the comparative agricultural years of the Angami and Sema Nagas, emphasizing the much more continuous labour of the latter on their dry fields, and the much greater leisure enjoyed by the former as well as a greater economic surplus from their irrigated terraces. This gave the Angami a much richer and more colourful social life, since more leisure and wealth are available for the fifth and sixth needs. Moreover, a concentration of population is possible, with consequent political influence and stability. He suggested further that the absence of leisure in dry cultivation may be a contributory factor in the specialization of village industries like pot-making and weaving, which (in the Naga Hills) are often alternatively practised in one village and *taboo* in a neighbouring one, and may thus have contributed to the formation of occupational castes. He described the difficulty, enhanced by ritual considerations and by the absence of perennial forest, of effecting a change from a dry to a wet economy; but when once achieved, such a change leads to much greater independence on the part of individual villagers and tends to reduce the power of individual chieftains.

Dr. E. R. Leach, who followed with a paper on dry rice cultivation in Burma and Borneo, took a very different view from Prof. Hutton. He repudiated any general dichotomy in the wet and dry cultivation, regarding them as complementary rather than alternative methods of agriculture, and treating the administrative condemnation of dry rice cultivation as based on incomplete knowledge and mere prejudice; advocates of a change from dry to wet, he said, ignore problems such as that of redistribution of labour involved in the change. Dr. Leach had worked out a most detailed analysis to compare the labour and results of three methods of agriculture: 'slash and burn' methods of cultivating on dry ground, cultivating with the hoe for dry or wet rice, and cultivating with the plough. The difference between them, he said, is more fundamental than that between dry and irrigated rice. His general conclusion was that the cultivation of dry rice is more productive in yield per unit of labour than wet rice unless the plough be used. This conclusion, he maintained, is confirmed by the preference both among the Kachin of Upper Burma and the Dusun of Borneo for the cultivation of dry rather than wet rice where both methods were available. He suggested that the Angami terracing is due to military considerations rather than economic. With the plough, of course, the area cultivated by a normal household can be so much increased that there is a much greater economic surplus.

Prof. Christoph von Fürer-Haimendorf discussed the two preceding papers in the light of his experience on the north bank of the Brahmaputra in Assam, where the Apa Tani tribe, using hoes and not ploughs, support a population of 1,000 to the square mile on irrigated rice, of which they have a considerable surplus to trade for cattle and cloth to the neighbouring Daflas, who live in comparative poverty on the cultivation of dry rice, also by the use of the hoe, and have repeatedly to shift their villages as land becomes exhausted. This supported Prof. Hutton's view that irrigated rice is economically more profitable than dry. The Apa Tani system of wet cultivation preserves all the soil fertility and yields a perfectly balanced agricultural economy. The Apa Tani are a peace-loving people whereas it is the Daflas who have a bias towards war.

In the discussion that followed, it became pretty clear first that there was general agreement that, *provided* a long enough cycle of rest can be depended on, dry cultivation of the hillsides, which may be the only possible form of cultivation, need not in the long run be destructive of the soil fertility, or at any rate is not so wasteful or deleterious as administrative and forest officers are inclined to assert; and secondly, that the question of the economic return of irrigated as compared to dry rice, per unit of labour expended, depends very largely on the rainfall and on the presence of a perennial water supply, a point which largely accounts for the different views put forward by Prof. Hutton, from his experience of the Assam hills, and by Dr. Leach, whose experience is of the drier climate of Upper Burma.

It was perhaps a pity that the discussion of primitive techniques was so largely limited to agriculture; but the importance of the subject was not left in any doubt.

NEWS and VIEWS

Prof. G. R. Goldsbrough, C.B.E., F.R.S.

Prof. G. R. Goldsbrough's retirement from the chair of mathematics at King's College, Newcastle-upon-Tyne, breaks a long and distinguished association with the College. He is an old student of the College, who returned to it in 1919 as lecturer in applied mathematics; in 1928 he was promoted to a professorship, and he has been head of the Department of Mathematics for the last three years. His research work has been mainly on two lines: in hydrodynamics he has made important contributions to the dynamical theory of the tides, and in astronomy he has elucidated the classical problem of the divisions in Saturn's ring. He was elected to the Royal Society in 1929. His interest in astronomy and geodynamics has been of special value in connexion with the work of the University Observatory at Durham. In addition to teaching and research, Prof. Goldsbrough has taken a leading and influential part in administrative and other activities in the University, and his sound judgment and advice have been greatly appreciated. He was sub-rector of the College for the period 1942–47; and among many other duties he undertook the arduous task of chairmanship of the Joint Recruiting Board. He was awarded the C.B.E. in 1948. His colleagues and old students will wish him in his retirement many pleasant years of fruitful activity. He has been succeeded at King's College by Profs. A. E. Green and W. W. Rogosinski (see *Nature*, September 18, p. 445).

Biological Chemistry at Aberdeen: Dr. W. O. Kermack, F.R.S.

Dr. W. O. Kermack, for many years in charge of the Chemical Laboratories of the Royal College of Physicians, Edinburgh, has been appointed to the recently established chair of biological chemistry in

the University of Aberdeen. This appointment will be received with a great deal of interest by all in the biochemical field, and with an element of surprise perhaps by some, for the appointment is probably unique in scientific circles in that Dr. Kermack is blind. To proceed to such an appointment in a laboratory subject has something in it of an act of faith, based not alone on the high scientific attainments but also on the rich mental endowments and sterling qualities of the new professor.

Dr. Kermack is an honours graduate in chemistry of the University of Aberdeen, where he received his B.Sc. degree in 1918. It was while a postgraduate research worker at Edinburgh that, in the course of an experiment, he met with the tragic accident which deprived him of all vision. To a lesser spirit such a catastrophe might well have spelt defeat; to Kermack it was but a challenge to re-orient his life to the steady continuance of his scientific work. That success has attended his efforts to a remarkable degree is seen in his activities in the spheres of mathematics, chemistry and music. His early research work was carried out in Oxford under the supervision first of Prof. W. H. Perkin and latterly of Sir Robert Robinson; his later work in colloid chemistry, on certain reactions of serum and cerebrospinal fluid, led on to the synthesis of compounds of possible antimalarial activity. This work has resulted in the synthesis of pyridoacridine and of *p*-phenanthroline derivatives, which have considerable chemotherapeutic activity on avian malaria. Dr. Kermack is joint author with Dr. P. Eggleton of "The Stuff We're Made Of" (1938); he is a D.Sc. of Aberdeen, was awarded the Freeland–Barbour Prize of the Royal College of Physicians, Edinburgh, the Macdougall–Brisbane Prize of the Royal Society of Edinburgh (1929), received the honorary degree of LL.D. of the University of St. Andrews in 1937 and was elected a fellow of the Royal Society in 1944.

Genetics at the John Innes Horticultural Institution

Dr. D. Lewis

Dr. D. Lewis is succeeding Dr. Mather, recently appointed to the chair of genetics at Birmingham, as head of the Genetics Department at the John Innes Horticultural Institution. Dr. Lewis was appointed from Reading in 1935 to work in the Pomology Department at the Institution. He has collaborated with Mr. M. B. Crane in the breeding of pears, raspberries and other fruits. For the last ten years, however, he has concentrated on the study of the incompatibility reaction in plants, using especially the Californian *Oenothera organensis*. He began with simple tests on the temperature relations. Later he introduced polyploidy and mutations, both spontaneous and induced, into his experiments. He has been able to split the incompatibility gene in *Oenothera*, with results of great physiological interest. He has also been able to calculate its natural mutation-rate in the sweet cherry, and at the same time use the mutations in producing self-fertile types in a hitherto self-incompatible species—a breeding device of great practical interest. Dr. Lewis' versatile experimental gifts should find suitable scope in his new post.

Women as a Labour Force in Britain

In Broadsheet No. 285, "Employment of Women", *Planning* (P.E.P.) examines some of the implications of the task of maintaining, and if possible increasing, the female labour of Britain at a time when the number of women of working age is declining. The difficulty is enhanced by the even greater decline in the number of women under forty-five years of age, from whom the bulk of the female labour force is drawn. The broadsheet points out that it is very important that employers should not be unprepared for the probable fall in the number of women in employment during the next fifteen years. The Ministry of Labour should forecast the probable trend in the number of women available for work in the various industries and regions, and should make the findings widely known. It must then be considered whether rising productivity will make good the loss of women workers, and if not, what adjustments should be made; in particular, whether to try to maintain the proportion of women in certain industries and occupations, or whether to allow the proportion to fall in all. Two conclusions stand out: first, that any substantial increase in the number of women in employment must come from married women; and, secondly, that if the female labour force is not to fall greatly, there must be a big rise in the number of middle-aged and elderly women in employment. By far the most hopeful means is to extend the opportunities for part-time workers. This is a desirable solution from the women's point of view; but from the employers' aspect entails careful organisation, additional supervision, and flexibility. In compensation there is evidence that part-time workers give good service, that their output is often higher than that of full-time workers, and that absenteeism and labour turn-over do not compare unfavourably. The importance of improving working conditions and providing more nurseries is stressed, and also of employing women who are in jobs to the best advantage. Those who aspire to a skilled, professional or executive job should have the opportunity, and the size, composition and distribution of the female labour force must not be left to chance.

French Abstracts

The *Bulletin Analytique*, published by the Centre National de la Recherche Scientifique, Paris, is an abstracting journal which appears monthly in two parts, Part 1 covering scientific and technical papers in the mathematical and physical sciences and their applications, Part 2 the biological sciences. The *Bulletin*, which started on a modest scale in 1940 with an average of 10,000 abstracts per part, now averages 35,000–40,000 abstracts per part. The abstracts summarize briefly papers in scientific and technical periodicals received in Paris from all over the world and cover the majority of the more important journals in the world scientific press. The scope of the *Bulletin* is constantly being enlarged to include a wider selection of periodicals. It thus provides a valuable reference book both for the laboratory and for the individual research worker who wishes to keep in touch with advances in subjects bordering on his own. A microfilm is made of each article as it is abstracted, and negative microfilm copies or prints from microfilm can be purchased from the editors. The subscription rates of the *Bulletin Analytique* for Great Britain are 4,000 fr. (£5) per annum for each part. The *Bulletin* is also issued in sections covering specific subjects. Subscriptions can be paid directly to the editors: Centre National de la Recherche Scientifique, 18 rue Pierre-Curie, Paris 5ème. (Compte-chèque-postal 2500–42, Paris), or through Messrs. H. K. Lewis and Co., Ltd., 136 Gower Street, London, W.C.1.

University of the Witwatersrand: Nuclear Physics Exhibition

THE chair of physics at the University of the Witwatersrand, Johannesburg, became vacant last year upon the retirement of Prof. H. H. Paine. The newly appointed head of the Department of Physics, Prof. G. T. R. Evans, delivered his inaugural lecture in the Great Hall of the University on September 23, taking as his subject "Radium: 1898–1948". Prof. Evans took the opportunity of paying a tribute to the memory of Madame Marie Curie and her husband. The vice-chancellor, Principal H. R. Raikes, who presided, expressed the appreciation of the University at the presence of M. Lancial, the Minister Plenipotentiary of the French Republic in South Africa. In connexion with the inaugural lecture there was held a two-day Exhibition in the Department of Physics under the direction of Prof. G. T. R. Evans. The film, "Marie Curie", was shown in the Great Hall; shorter films, "The Nuclear Structure of the Atom" and "Atomic Energy", were shown in the lecture theatre of the Department. The exhibition of nuclear phenomena, apparatus and films was open daily from 2.30 p.m. and attracted several thousand people. The exhibits included items of historic interest contributed by Madame Irene Joliot-Curie. Prof. A. M. Tyndall, of the University of Bristol, exhibited a collection of photomicrographs of nuclear tracks in photographic emulsions. The National Physical Laboratory of Pretoria demonstrated artificial radioactivity in biology. Other exhibits appreciated by the lay public were a working model of a cyclotron, a Wilson cloud chamber, Geiger counters and scalars, the medical use of radium and South African fluorescent minerals. This is the third exhibition organised by the Department of Physics since 1945; the crowds which gathered round the demonstrators until long after the hour for closing constituted convincing evidence of the appreciation of the Department's efforts to meet the layman's desire for a better understanding of modern physics.

Medical Research Council: New Members

BY an Order of the Committee of Privy Council for Medical Research, Lord Addison and Sir George Schuster have been appointed members of the Medical Research Council. With the approval of the Committee of Privy Council, the Medical Research Council has appointed Lord Addison to be its chairman in succession to Lord Balfour of Burleigh, and Sir George Schuster to be treasurer in succession to Sir William Goodenough. By the same Order, made in this respect after consultation with the Medical Research Council and with the president of the Royal Society, the following have also been appointed members of the Council: Sir Frederic Bartlett, professor of experimental psychology in the University of Cambridge; Sir Howard Florey, professor of pathology in the University of Oxford; and Prof. Geoffrey Jefferson, professor of neurosurgery in the University of Manchester.

Permanent International Association of Navigation Congresses

THERE has recently been formed, with the approval of the Ministry of Transport, a British National Committee in connexion with the Permanent International Association of Navigation Congresses. The main objects of the Committee are to foster interest in the Association, to promote papers for presentation at the congresses (in particular for the next congress to be held in Lisbon in September 1949) and generally to act as the co-ordinator of British interests in this connexion. The membership of the Committee is as follows: Sir William Halcrow (chairman), Mr. M. G. J. McHaffie, Mr. W. P. Shepherd-Barron, Mr. R. D. Gwyther, Mr. A. L. Harvey, Mr. C. A. Wilson, Mr. L. Cleaver, Sir Gilmour Jenkins, Mr. L. Leighton, Sir Cyril Kirkpatrick, Sir Arthur Whitaker and Mr. Maurice Nachshen. The Council of the Institution of Civil Engineers will administer and provide secretarial facilities to the National Committee. The Committee, at the request of the Secretary-General of the Association, has agreed to distribute in Great Britain bulletins, etc., received in bulk from Brussels, and also to receive on behalf of the Association subscriptions from members resident in Britain for onward transmission in a bulk sum or sums. Correspondence should be addressed to the Secretary, British National Committee, Permanent International Association of Navigation Congresses, at the Institution of Civil Engineers, Great George Street, London, S.W.1.

Royal Aeronautical Society

THE Royal Aeronautical Society has decided to form Divisions of the Society within the British Commonwealth, and steps are being taken to establish such Divisions in Australia and also in New Zealand by January 1, 1949. These Divisions (and those in other Dominions as formed) will have power to form branches of the Royal Aeronautical Society in their own countries, similar to those formed by the Society in Great Britain. Members of the Division will all be full registered members of the Society, and the Division will have the power to act in most respects exactly as the parent body in London. The only important exception is the actual election of members as associate fellows, so that a consistent standard will be set throughout the world; all such technical members will be elected by the Royal Aeronautical Society in London. But the Divisions will follow their own activities in their own countries in the ways which best suit that country and local conditions, and they will not be tied down in any way by rules or regulations which apply to Great Britain or the other Divisions.

Society for General Microbiology

AT a general meeting of the Society held at St. Andrews in September, the following were elected honorary members of the Society: Prof. O. T. Avery, Prof. Jules Bordet, Sir Alexander Fleming, Prof. A. J. Kluyver and Sir Charles Martin. In addition, a paper-reading session was held over two days, and thirteen demonstrations were given.

The officers and committee of the Society for 1948–49 are as follows: *President*, Dr. Marjory Stephenson; *Hon. Treasurer*, Mr. H. J. Bunker; *Joint Hon. Secretaries*, Dr. W. E. van Heyningen and Dr. J. G. Davis. The *Journal* of the Society is issued at about four-monthly intervals, and is edited by Dr. B. C. J. G. Knight and Dr. A. A. Miles, assisted by Dr. G. C. Ainsworth, Prof. W. B. Brierley, Dr. T. Gibson, Dr. A. T. R. Mattick, Dr. K. M. Smith, Dr. A. W. Stableforth and Dr. D. D. Woods.

Fourth Empire Mining and Metallurgical Congress

THE Fourth Empire Mining and Metallurgical Congress convened by the Empire Council of Mining and Metallurgical Institutions will be held in Great

Britain in July 1949, under the presidency of Sir Henry Tizard. The chief object of the Congress is to afford an opportunity for scientific men, engineers and others concerned with the mining and metallurgical industries to meet and discuss technical progress and problems, including the development of the mineral resources of the Commonwealth. The programme will be divided into three parts: July 9–12, inaugural meeting, official functions, exhibitions, visits, etc., in London; July 13–17, technical sessions in Oxford; July 18–23, excursions based for the most part on universities in Great Britain. Further information can be obtained from the General Secretaries, Fourth Empire Mining and Metallurgical Congress, 436 Salisbury House, Finsbury Circus, London, E.C.2.

Colonial Medical Research Fellowships

THE Secretary of State for the Colonies has instituted a limited number of research studentships for graduates in medicine and cognate sciences, who desire by this means to prepare themselves for research work in tropical medicine and related subjects. They will be awarded on the advice of the Colonial Medical Research Committee, and will be tenable for two years at any university or other appropriate institution as approved by the Committee. The maximum rates of allowance payable are £300 per annum at the Universities of Oxford, Cambridge and London, and £260 per annum at other universities in the United Kingdom. Candidates must be British subjects and graduates of British universities. Application should be made, through the head of the candidate's Department, to the Secretary, Colonial Medical Research Committee, c/o Research Department, Colonial Office, Sanctuary Buildings, Gt. Smith Street, London, S.W.1, and should include, in addition to details of the candidate's academic record, some indication of the subject preferred.

A General Solution for the Force Constants of Polyatomic Molecules

MR. P. TORKINGTON writes with reference to the communication under the above title in *Nature* of September 4, p. 370: "It was stated that in the proposed solution the normal co-ordinate for ν_i involved only the co-ordinates Δ_i to Δ_n. In fact, it involves only the co-ordinates Δ_1 to Δ_i. The linear transformation giving the (unnormalized) normal co-ordinates η_i is found to be

$$\eta_i = \sum_{j=1}^{i} (i|A|ij)\ \Delta_j.$$

The quantities on the right-hand side of equations (7) and (8) are coefficients in the reverse transformation, giving here the components in the displacement for ν_k in terms of η_k. In (8), the coefficients for Δ_1 to Δ_{k-1} are zero; it is therefore the form of the vibration, not the normal co-ordinate, which involves Δ_k to Δ_n only. Where $(\nu_i - \nu_{i+1})$ is small, and Δ_i and Δ_{i+1} overlap, η_i would be expected to involve Δ_{i+1}; η_{i+1} involves Δ_i in any event."

Announcements

THE Lords Commissioners of the Treasury have appointed Dr. A. E. Trueman to be chairman of the University Grants Committee in succession to Sir Walter Moberly, who retires on October 1, 1949. Dr. Trueman, who has had a distinguished career as a geologist and a university administrator, became deputy chairman of the Committee in 1946 (see *Nature*, August 31, 1946, p. 299).

DR. ROBERT CRUICKSHANK, since 1945 director of the Central Public Health Laboratory of the Public Health Laboratory Service, has been appointed to the chair of bacteriology tenable at St. Mary's Hospital Medical School, London, as from January 1, 1949.

DR. R. A. M. CASE, until recently a principal scientific officer in the Royal Naval Scientific Service at the Royal Naval Physiological Laboratory, has taken up appointment at the Chester Beatty Research Institute of the Royal Cancer Hospital as research fellow under a scheme inaugurated by the Association of British Chemical Manufacturers, for the field and experimental investigation of the industrial incidence of papilloma of the bladder.

DR. T. T. PATERSON, who has resigned his post as curator of the Museum of Archæology and Ethnology, Cambridge (see *Nature*, September 18, p. 445), is to devote his time to research in the social anthropology of Britain, with special reference to problems of social medicine and group phenomena in the industrial, rural and urban fields. The investigation is being financed by a grant from the Medical Research Council.

THE Leon Gaster Memorial Premium of the Illuminating Engineering Society, given annually for the best contribution submitted to and published by the Society during the session, has this year been awarded to Mr. J. N. Bowtell and Mr. H. G. Jenkins for their paper entitled "High Voltage Fluorescent Tubes". In view of the high standard of papers eligible for the award this year, the Council has made a second award to Messrs. H. K. Cameron, E. H. Rayner, E. R. Thomas and G. T. Winch for their paper entitled "Photometry of Searchlights" which forms part of the "Symposium on Searchlights" recently published by the Illuminating Engineering Society.

THE Tilden Lecture of the Chemical Society will be delivered by Prof. C. E. H. Bawn in the rooms of the Society on November 11 at 7 p.m. Prof. Bawn will speak on "The Structure and Reactivity of Free Radicals".

A COURSE of eight lectures on practical psychical research, beginning on October 16, has been arranged by the Society for Psychical Research and will be given at its house, 31 Tavistock Square, London, W.C.1. The topics to be discussed include the investigation of cases, extra-sensory perception experiments, and psychological and statistical methods. Tickets of admission (one ticket covers the whole course) can be obtained free from the secretary of the Society.

DR. B. P. DUDDING, honorary lecturer in industrial statistics, University of Sheffield, will give a course of eight lectures at the Sir John Cass Technical Institute, London, E.C.3, on Monday evenings at 7 p.m., beginning on October 25, on "Statistical Methods in Industry". A further course of lectures, also on Mondays at 7 p.m., beginning January 24, will be given by Mr. K. A. Brownlee on "Design of Experiments". The fee for either course is £1. Application for enrolment forms should be made to the Principal of the Institute prior to the opening date of the courses.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Structure of Calciferol

For some time it has appeared very desirable to undertake, for a calciferol derivative, a detailed X-ray analysis similar to that achieved for cholesteryl iodide[1]. Such an analysis should settle once for all many doubtful points in sterol chemistry and, incidentally, resolve the conflict between the early crystallographic and chemical evidence on the structure of calciferol[2]. The X-ray analysis of cholesteryl iodide was possible owing to the presence of the heavy iodine atom in the molecule, which permitted the direct calculation of electron-density projections. In the case of calciferol, our chief difficulty has been in finding any crystalline heavy-atom derivative. Dr. and Mrs. Cornforth were finally successful in preparing for us crystals of calciferol-4-iodo-5-nitrobenzoate, and from these we have now obtained evidence, by X-ray analysis, on the molecular structure of calciferol.

The crystals of calciferol-4-iodo-5-nitrobenzoate, $C_{35}H_{46}NO_4I$, are deep yellow prisms. They are orthorhombic with four molecules in the unit cell of dimensions: $a = 31{\cdot}2$, $b = 6{\cdot}98$, $c = 15{\cdot}3$ A., and space group $P\,2_12_12_1$. Their investigation followed a somewhat similar course to that adopted in the case of cholesteryl iodide. The x and z parameters of the iodine atoms were first found from a calculated Patterson (F^2) projection based on the intensities of the ($h0l$) reflexions. The first electron density projection was then calculated, using reflexions the phases for which could be determined from the iodine atom contributions alone; this projection indicated the configuration of the molecules and their general arrangement in the crystal. Approximate x and z parameters were then assigned to the other atoms in the crystal from this first projection. These parameters were refined and, in some cases, entirely changed through the calculation of two further electron density projections, based on phases calculated for all the atoms in the molecule. The final projection obtained is shown in Fig. 1 *a*, and its interpretation in terms of atomic positions in Fig. 1 *b*.

We have not so far completed the measurements on other zones of the crystal, so that we have, at present, no evidence on the y parameters normal to this (010) projection. While it should be simple to determine the y parameters of the iodine atoms, a prolonged and difficult three-dimensional analysis will be required to derive the y parameters of the remaining atoms.

We have, however, been fortunate in the crystal found for X-ray analysis. The fact that b is so short, 6·98 A., has given us a projection normal to this axis in which atoms of neighbouring molecules do not overlap; as a result, we have a projection of the calciferol structure which provides surprisingly good evidence on almost every detail of the chemical and stereochemical nature of the molecule. There is, in the first place, no doubt that ring *B* of the sterol skeleton is broken and that structure I, deduced on chemical evidence[2] for calciferol, is correct. In our crystal, however, the molecule does not maintain the curled-up configuration suggested by I, but exists in an extended form which may be approximately represented by II.

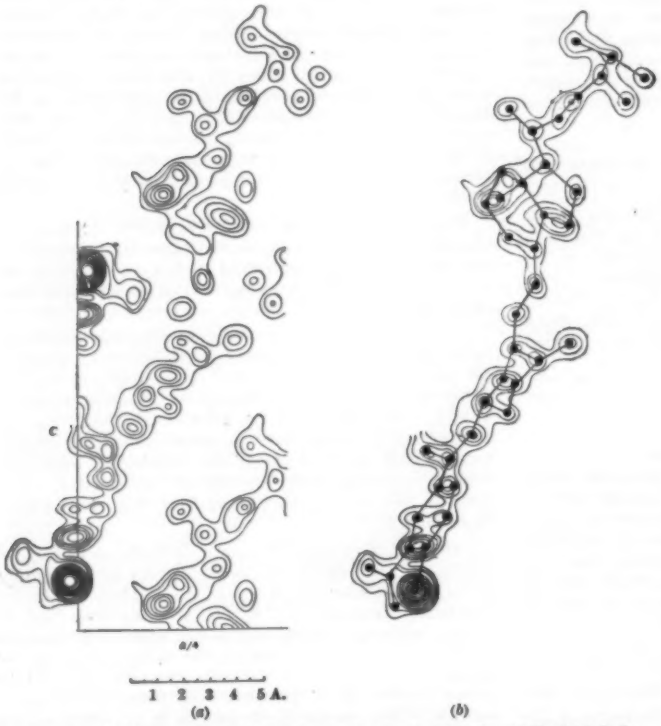
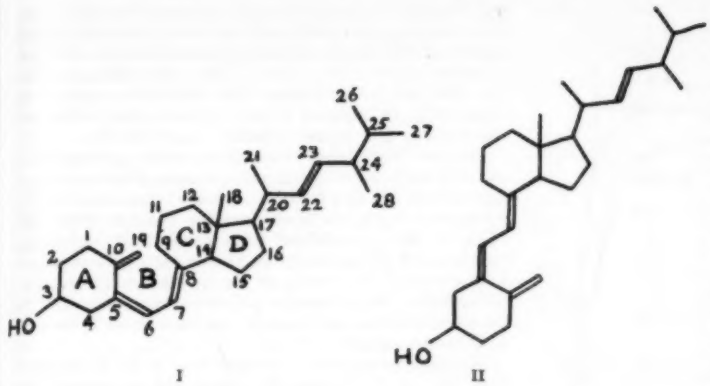


Fig. 1. (*a*) Electron density projection on (010) calculated for calciferol-4-iodo-5-nitrobenzoate. (*b*) The same with, superimposed, the positions derived for the atoms in the molecule. In both (*a*) and (*b*) only the electron density contours covering one of the four molecules which appear in this projection are shown in full

The detailed stereochemical relations of the atoms within the molecule (Fig. 2) are naturally interdependent; they may conveniently be traced from the point of attachment of the iodonitrobenzoyl group. First, the direction of the C(3) — O bond is only consistent with that described by Ruzicka, Furter and Goldberg as *t* or *'trans'*[4] in the original sterol skeleton (that is, *cis* to the methyl group at C(10) and C(13) in the ergosterol skeleton before ring breaking). This configuration is the same as that found for C(3) — I in cholesteryl iodide (cf. Dimroth[5]). Ring *A* itself has the expected appearance of a puckered six-membered ring in the 'chair' or *Z* form seen on its side. The directions at which the bonds C(10) — C(19) and C(5) — C(6) project are consistent with these being double bonds;



I II

again, C(7) — C(8) is nearly parallel in projection with C(5) — C(6), as might be expected in a double-bonded system. Rings *C* and *D* are seen open in projection. Their appearance, particularly the parallel projection of bonds C(9) — C(8) and C(14) — C(15) combined with the position of C(16), seems only consistent with *trans* fusion of these two rings. The stereochemical relations at the centres C(13), C(17) and C(20) are as found in cholesteryl iodide, and the relation of these to the new asymmetric centre in calciferol at C(24) is shown. The main doubt that exists at present in the determination of these different points in configuration is in the relation of the two parts of the molecule separated by C(6) and C(7) (hence in the C(3) — O bond configuration). The relation described above depends on the probability that the bonds C(5)—C(6) and C(7) — C(8) are parallel in three dimensions. This probability is high, both on theoretical grounds and through the appearance of the projection. It will in any case be checked by the three-dimensional X-ray analysis of the structure.

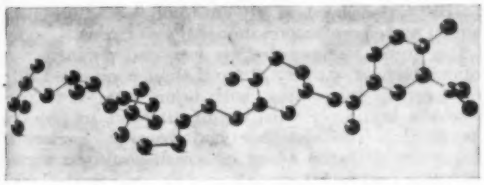


Fig. 2. Photograph of model showing the spatial arrangement of the atoms in calciferol-4-iodo-5-nitrobenzoate required by the electron density projection 1 *a*. This model shows one of the two permissible mirror-image forms of the molecule. The form chosen corresponds to the usual convention in the sterol series; compare, for example, Ruzicka *et al.* (ref. 5): it is not that given for cholesteryl iodide (see ref. 1). Hydrogen atoms are omitted

The way in which the molecules are fitted into the crystal structure as a whole is very intricate; it is one to which the unit-cell dimensions give no clue. It seems, therefore, quite possible that some similar unsuspected crystallographic complications exist in the calciferol crystals which were earlier examined, and that these led to a misinterpretation of the preliminary X-ray data. It is also conceivable that the calciferol molecule may adopt more bent or curled-up configurations in other crystals than that found here. Such differences could not affect the detailed chemical and stereochemical relations which are now clearly established.

In conclusion, we should like to thank those who helped us in our search for heavy-atom derivatives of calciferol, particularly Sir Robert Robinson, Dr. E. H. Carr, Dr. E. R. H. Jones, Dr. and Mrs. Cornforth and Dr. P. Meunier. The compound we used was first prepared in the Dyson Perrins Laboratory, Oxford, by Mrs. R. Cornforth from material given to us by Dr. E. H. Carr (British Drug Houses, Ltd.). It was later prepared in larger quantities at the National Institute for Medical Research, Hampstead, by Dr. J. W. Cornforth.

DOROTHY CROWFOOT
J. D. DUNITZ
Laboratory of Chemical Crystallography,
Oxford. July 12.

[1] Carlisle, C. H., and Crowfoot, D., *Proc. Roy. Soc.*, A, **184**, 64 (1945).
[2] Bernal, J. D., Crowfoot, D., and Fankuchen, I., *Phil. Trans. Roy. Soc.*, A, **239**, 135 (1940).
[3] Lettre, H., *Ann. Chem.*, **511**, 280 (1934). Heilbron, I. M., Samant, K. M., and Spring, F. S., *Nature*, **135**, 1072 (1935). Windaus, A., and Thiele, W., *Ann. Chem.*, **521**, 160 (1935).
[4] *Helv. Chim. Acta*, **21**, 498 (1938).
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Surface Layers of Crystals

CERTAIN treatments of crystal surfaces result in the formation of surface layers with physical properties different from those of the undisturbed material[1-3]. It has hitherto been possible to measure the thickness of such a layer only by etching it away until the properties of the surface thereby revealed correspond to those of the crystal as a whole[4]. This method is unsatisfactory in that the effect of etching is uncertain: it does not take place uniformly, and it results in pitting, which may lead to erroneous estimates of layer thickness.

We have devised an X-ray method which yields the thickness of the surface layer without altering it physically. The method is described in detail elsewhere[5]: it involves measurement of the variation in the intensity of X-ray reflexion from a crystal, as the angle φ (Fig. 1), between the surface and the Bragg reflecting planes, is varied. The surface of the crystal is cut so that it is inclined at an angle ω to the Bragg planes, and by rotating the crystal about an axis normal to the planes the effective value of φ

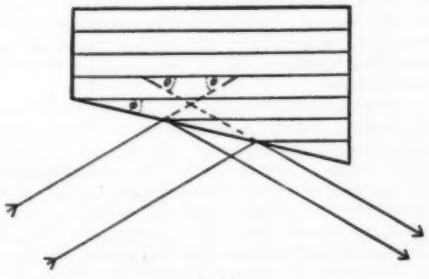

Fig. 1

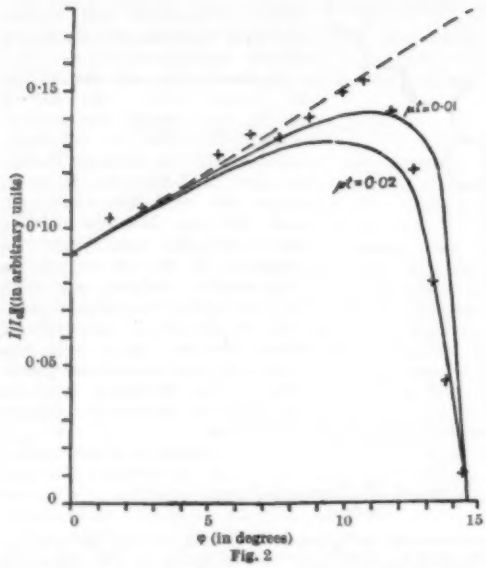

Fig. 2

may be made to vary from zero to ω, without disturbance of the surface.

For a crystal with no surface inhomogeneities an expression has been developed[6] for the ratio I/I_0 of reflected to incident beam intensity which is represented (suitably scaled) by the dotted line in Fig. 2. If, however, there are surface inhomogeneities such that the reflexion coefficient (K_0') and absorption coefficient (μ') differ from the values ($K_0\mu$) appropriate to the main part of the crystal, then the variation of I/I_0 will follow a different law. A type of inhomogeneity particularly convenient for mathematical treatment is one where there is a surface layer of thickness t in which $K_0' = 0$ but $\mu' \neq 0$. The variation of I/I_0 with φ, for $\mu't = 0{\cdot}01$ and $\mu't = 0{\cdot}02$, is represented (suitably scaled) by the full lines in Fig. 2.

Other assumptions may be made about the variation of K_0' with depth (for example, a linear increase up to the full value K_0); but provided it be taken as an increasing function and μ' be taken as constant throughout the layer, curves very similar to those shown in Fig. 2 result. If the layer thickness be defined as the distance between the surface and the point where $K_0' = \frac{1}{2}K_0$, then it is found that the values of this thickness are almost independent of the particular assumptions made about the variation of K_0'. Thus the method, while yielding a reasonable estimate of this half-value layer thickness, which is, of course, subject to some uncertainty about the value of μ', gives no information about the way in which K_0' varies; except that, to explain the zero or very low value of I/I_0 at $\varphi = 0$, it is in all cases necessary to assume K_0' to be zero or very small at the surface.

We have applied this to determine the thickness of the surface layer on a crystal of calcite ground and polished at an angle ω of 15° to a natural cleavage face. Electron diffraction photographs taken by reflexion from this surface showed intense background with slight central halation, such as one would expect from an amorphous material[2], justifying the assumption that K_0' is zero at the surface. Applying the X-ray method described above, we obtained the experimental points shown in Fig. 2, which agree reasonably well with a theoretical curve, based on the above simplifying assumptions, and for a value $\mu't \sim 1{\cdot}5 \times 10^{-2}$. For crystalline calcite $\mu = 205$ cm.$^{-1}$ for copper $K\alpha$ radiation, and it is reasonable to assume that it is not very different throughout the layer. Hence $t \sim 7{,}500$ Å.

We are using this method to study ground and natural surfaces of single crystals and polycrystalline aggregates. It should be possible to measure by this means the thickness of any surface layer in which the value of K_0' is different from that of the substrate material: one example is the layer on a polished metal surface, for which we have obtained interesting preliminary experimental observations; another is an electrodeposited layer of one metal on a base of a different metal.

We wish to express our thanks to Dr. V. E. Cosslett and Mr. G. R. Crowe for their aid in taking the electron diffraction photographs.

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Ionization in Liquid and Solid Argon

Ionic mobilities in liquids are of the order of 10^{-3} cm.^{2}/volt/sec., and ion chambers filled with liquids are therefore generally useless in connexion with pulse amplifiers. Free electrons should have a much higher mobility; but their path before capture is extremely short in most liquids. We have been unable to detect them in carefully purified hexane. However, in condensed argon, charge carriers with a mobility greater than 40 cm.^{2}/volt/sec. have been found, and these are undoubtedly electrons.

The argon was purified by repeated passage over copper turnings at 400° C., and then condensed into the chamber by cooling, with liquid oxygen to produce the liquid, or with liquid nitrogen to produce the solid. The chamber had parallel, horizontal plates the distance apart of which could be varied between 1 and 5 mm.

The biggest pulses observed with liquid argon irradiated with gamma rays from radium C were, with fields of 10,000 volts per cm., about what was expected from complete electron collection (assuming an average energy loss by the Compton electrons of 25 eV. per ion pair formed). The pulses are distinctly smaller in fields of 2,500 volts per cm.

In solid argon much bigger pulses were found with fields of more than 13,000 volts/cm., indicating electron multiplication by a factor of more than 12. This phenomenon is, however, transient and disappears at a rate depending on the rate of charge collection as the cell polarizes. The polarization is not just due to the possible presence of a gas space between the solid and the top electrode, because it still occurs when the top portion of the cell is filled with liquid. The effect is similar to that reported in diamond and selenium[1].

If, after polarization had occurred, the chamber potential was removed, pulses continued with the same sign, in contrast to the reported behaviour[2] of silver chloride crystals, which show pulses of the opposite sign. This difference may be connected with the occurrence of secondary ionization in the argon in the fields used. If the cell contained a layer of solid argon below and liquid argon above, the predominant sign of the pulses after switching off the field always corresponded to an accumulation of positive space charge in the solid, no matter which had been the sign of the polarizing field.

An attempt was made to observe electron multiplication in the liquid by the use of a proportional counter made with a 15-micron wire in a cylinder of 5·2 mm. diameter; but only ordinary sized pulses were observed up to the maximum potential of 4,000 volts. In the solid, multiplication greater than ten-fold was found at potentials as low as 500 volts, but polarization was too rapid for accurate measurement.

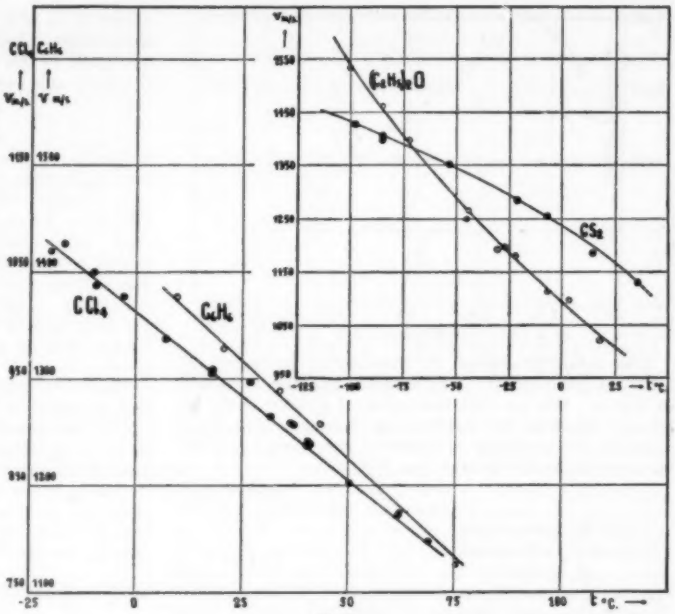

Fig. 1

Further information was obtained with a chamber in which the upper (collecting) electrode was screened by a fine wire grid. Pulses were observed with solid argon in part of the lower portion of the cell (the remainder containing the gas), but not when the solid was replaced by liquid. This indicates that in the fields used (greater than 500 volts/cm.), some electrons in the solid but not in the liquid have enough energy to escape into the gas phase.

Properties of ionization pulses in liquid and solid argon and other condensed media have recently been reported[3]. These experiments were done with alpha-particles and produced pulses about half the expected size. This is perhaps due to recombination, because of the denseness of the ionization tracks, and the effect may well be absent when ionization is due to fast electrons as in our experiments.

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Sound Velocity and Temperature Change of Molecular Association

Using an acoustical interferometer (frequency of the quartz crystal, 539·6 kc./s.), we have measured the velocity of sound in various liquids (carbon tetrachloride, benzene, ethyl ether and carbon disulphide) between 80° C. and the melting point of these liquids (see Fig. 1). In order to check the degree of association of the liquids at low temperatures, we computed from our measurements the relative association: $R = (v_m^{1/3}/d_m)/(v^{1/3}/d)$, using the empirical equation of Rao[1], which has also been applied by Weissler[2].

v and d are the velocity of sound and density corresponding with the same temperature. In the case of no association, R is a constant.

This relative association (see Fig. 2) is taken as 1·000 at the respective melting points. The values for v_m are obtained by extrapolating our data down to the melting point. The values for the densities are taken from data published respectively by Isnard[3], Meyer[4], and by Richards, Speyers and Carver[5]. From Fig. 2 we see that an approximately straight line is obtained for carbon tetrachloride, while for the other liquids the lines are curved. The result for water obtained by Weissler[2] is also indicated.

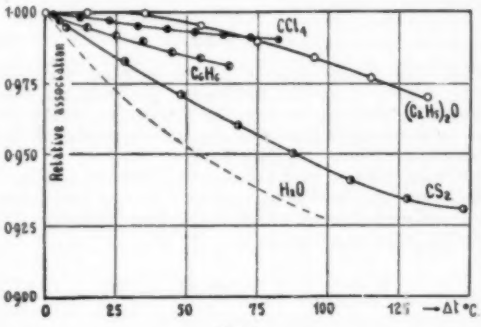

Fig. 2

In connexion with this problem of association, it is interesting to compute the relative association for helium I and II, using for this purpose the known experimental data for the velocity of sound obtained by Findley, Pitt, Grayson Smith and Wilhelm[6], and Pellam and Squire[7], and the densities of liquid helium under its saturated vapour pressure (Keesom and Keesom[8]).

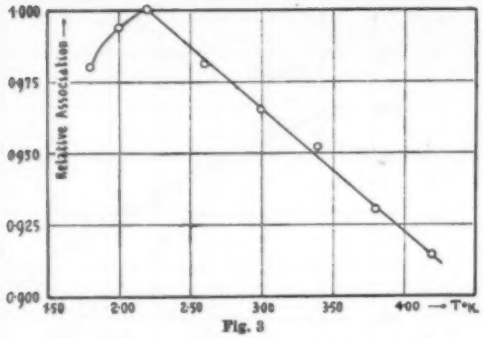

Fig. 3

The relative degree of association is taken as 1·000 at the λ-point. The results obtained are given in Fig. 3. We see that for helium I a straight line is found, whereas for helium II the line is curved. Further, the decrease of relative association is of the same order as for water[8] (see Fig. 2).

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Magnetism of Celestial Bodies and Gravitation

Blackett's formula[1] involving a relation between mechanical and electromagnetic quantities seems to indicate a new kind of connexion between gravitation and electromagnetism. This appears more distinctly in Wilson's relation:

$$\sigma = \sqrt{K}\rho, \tag{1}$$

where the charge density σ is associated with the mass density ρ by the Newtonian gravitational constant K. There is no room in Newtonian theory for an explanation of (1). The situation is better in the relativistic theory of gravitation.

For an isolated and limited fluid surrounded by a static gravitational field, and at rest with respect to a co-ordinate system which is Galilean at infinity, the total energy is given by[2]:

$$E = \int (T_4^4 + t_4^4)\, dV = mc^2, \tag{2}$$

where T_4^4 is the temporal component of the momentum-energy density tensor of the fluid, t_4^4 the temporal component of the gravitational energy density, dV the element of proper volume and *m the proper mass of the fluid*, equal to the constant of Schwarzschild's external line element[3]. For a sphere it is approximately equal to[4]:

$$E = \int_v \rho c^2\, dV + \tfrac{1}{2}\int_{V_0} \rho\psi\, dV_0, \tag{3}$$

where ψ is the Newtonian potential and dV_0 the elementary Euclidean volume, the integral being extended to the domain occupied by the fluid. When the body is a perfect spherical fluid[5] we have:

$$-3\int p\, dV_0 = \tfrac{1}{2}\int \rho\psi\, dV_0, \tag{4}$$

where p is the internal pressure. In Newtonian approximation, dV reduces to the Euclidean elementary volume dV_0 and (3) yields: $E = mc^2 - W$ ($W = -\frac{1}{2}\int \rho\psi\, dV_0$). Therefore (2) indicates that there is in relativity a supplementary energy W which is such that according to (2) $E = mc^2$. The same conclusion is valid if the field of force inside the body is given by Schwarzschild's line element for a spherical incompressible fluid. This can be easily checked by computation of (2), using Dingle's formulæ[6].

The existence of W is due to the fact that the first integral in (3) is extended over a non-Euclidean space, for which the total volume occupied by the fluid is greater than that obtained by using a Euclidean metric. In spite of the very small difference between these volumes, the supplementary energy obtained in this way is not negligible. In Schwarzschild's case, with a as the Euclidean radius of the sphere, we get[7]:

$$m'c^2 = \int \rho c^2\, dV = \rho\,\frac{4\pi}{3}\,a^3\left[1 + \frac{3}{5}\frac{Km}{c^2 a} + \ldots\right], \tag{5}$$

and thus we obtain the supplementary energy[8]:

$$W = m'c^2 - mc^2 = \frac{3}{5}\frac{Km^2}{a}. \tag{6}$$

The physical origin of this energy is unknown. Obviously, it cannot be attributed to the internal pressure or to the Newtonian action of the gravitational field. Let us assume that it is due to a partial separation of the charges contained in the atoms of the neutral fluid. To support this hypothesis we must notice that an atom which possesses spherical symmetry and no permanent electric moment in a Euclidean space has ellipsoidal symmetry and a small permanent electric moment in Schwarzschild's internal field, as will now be shown. Schwarzschild's internal spatial line element is:

$$dl^2 = dr^2\Big/\left(1 - \frac{2Kmr^2}{c^2a^3}\right) + r^2\,(d\theta^2 + \sin^2\theta\, d\varphi^2). \tag{7}$$

According to (7), the length measured in the direction perpendicular to the radius r is the same as in Euclidean geometry, while the length measured along this radius,

$$\int dR = \int \left(1 + \frac{Kmr^2}{c^2a^3}\right) dr, \tag{8}$$

is greater[9]. Therefore, a sphere is changed into an ellipsoid by penetrating into the fluid. This involves, owing to the structure of the atoms, a small polarization.

But we cannot directly use such a precise mechanism, because it is special to Schwarzschild's co-ordinate system. In an isotropic system, the Euclidean length is modified by the curvature of the space in the same manner whatever the orientation[10]. However, in spite of the indeterminacy of the co-ordinate system, since the electric charge is a relativistic invariant, the existence of such a charge in a special co-ordinate system ensures its existence in all others. We have only to admit that the relativistic expansion of the internal space induces a partial separation of

the charges of the two signs composing the neutral fluid. Having assumed that the electrical energy which results from such a separation is equal to the supplementary energy (6), we now obtain (1).

According to (5) and (1) the total charge resulting from the separation is $e = \sqrt{K}\int \rho\, dV$. The fact that the non-Euclidean volume of the fluid exceeds the Euclidean volume of the Newtonian physics gives rise to an additional charge which is given by:

$$\varepsilon = \sqrt{K}\int \rho\,(dV - dV_0)$$

$$= \sqrt{K}\rho\,\frac{4\pi}{3}\,a^3\left(\frac{3}{5}\,\frac{Km}{c^2a}\right) = \left(\frac{\sqrt{K}\rho\, Km}{5c^2}\right)4\pi a^2. \qquad (9)$$

This can be regarded as a surface charge of density $\eta = \dfrac{K^{3/2}\rho m}{5c^2}$. For the earth, the computation gives $\eta = 1{\cdot}26 \times 10^{-4}$ e.s.u./cm.^{2}. The experimental facts indicate that the surface of the earth possesses a negative charge the average density of which is $-2{\cdot}7 \times 10^{-4}$.

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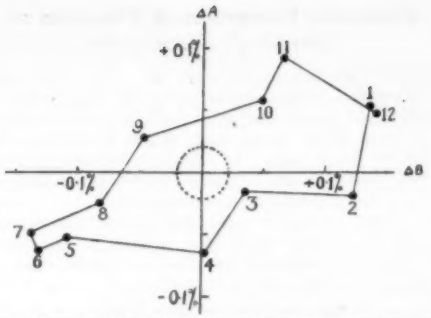
Sidereal Variations of Cosmic Rays

Duperier[1] has analysed the first harmonic of the apparent solar diurnal variation of cosmic rays at London, using a method due to Thompson[2]. He finds that the first harmonic for any month has three components, namely, (i) a mean solar vector M, (ii) a vector, A, altering the amplitude of M, and (iii) a vector, P, controlling the change of phase of M. The P vector may arise from either (*a*) a sidereal diurnal variation, (*b*) an annual solar variation, or (*c*) a combination of these effects. This communication discusses the interpretation to be placed on the P vector, by comparing Duperier's figures for London with the results obtained at Canberra.

The Canberra results were obtained with an ionization vessel and were corrected for bursts, pressure and temperature[3]. A harmonic analysis was made of the apparent solar diurnal variation averaged for each month of the year over a period of five years. From these analyses a harmonic dial was constructed showing the month-to-month change of the first diurnal harmonics. Smoothed points in this dial progressed clockwise in a closed figure, as found also by Duperier. An ellipse was fitted to the unsmoothed points by harmonic analysis of the deviations from the mean solar vector, and this gave the vectors A and P for comparison with Duperier's data. The accompanying table shows that the P vector, interpreted as a sidereal effect, exhibits a phase difference of about twelve hours between the northern and southern station. It seems preferable, therefore, to regard the P vector as representing, in the main, merely an annual change in the phase of the true solar diurnal variation, making the diurnal maximum occur earliest in the spring at both places.



Annual changes in the deviations from the mean of the cosine (A) and sine (B) components of the first harmonic of the apparent solar diurnal variation of cosmic rays at Canberra, arranged according to local mean time. 1 = Jan.; 2 = Feb., etc. The central circle indicates the probable error of the monthly points (± 0·02 per cent)

If the P vector is regarded as being of solar origin, it is appropriate to reduce the results according to local apparent time rather than local mean time. Local apparent time values for A and P are slightly smaller for the former than for the latter. It seems that any sidereal variation of cosmic rays with a 24-hour period would be extremely small, for the P vector (local apparent time) of 0·03 per cent (equivalent to a maximum change of phase of about 10 min.) would have to take account of not only the sidereal process, but also of any change in the lag between the cosmic rays and the sun's position. It seems likely that no 24-hour sidereal variation has been detected in these measurements, and that, in terms of the theory advanced by Compton and Getting[4], an interstellar rather than an intergalactic origin should be assigned to cosmic rays.

Analysis of the first harmonic of the apparent solar diurnal variation of cosmic rays

Vector	London (local mean time)		Canberra (local mean time)		Canberra (local apparent time)	
	Amplitude % ± p.e.	Time of maximum	Amplitude % ± p.e.	Time of maximum	Amplitude % ± p.e.	Time of maximum
M	0·41 ± 0·02	16·3h. (L.M.T.)	0·67 ± 0·02	15·0 ± 0·1h.	0·67 ± 0·02	15·0 ± 0·1h.
A	0·36 ± 0·02	June-	0·22 ± 0·02	Mar. 27 ± 12d.	0·20 ± 0·02	Apl. 7 ± 12d.
P(*a*) Sidereal ..	0·21 ± 0·02	21h. (L.S.T.)	0·05 ± 0·02	9·6 ± 0·7h. (L.S.T.)	—	—
(*b*) Solar	0·21 ± 0·02	March-	0·05 ± 0·02	Sep. 25 ± 12d.	0·03 ± 0·02	Nov. 12 ± 12d.

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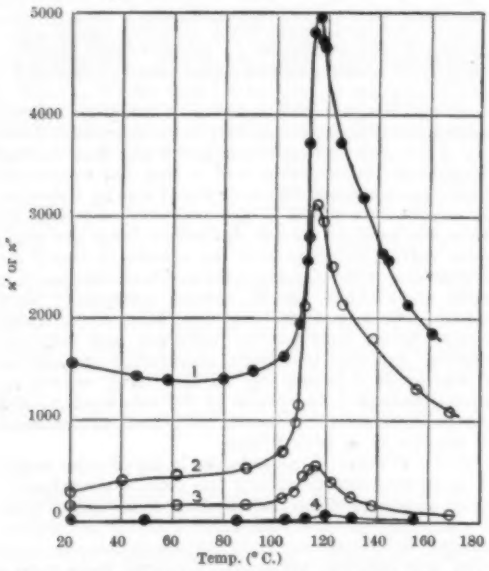
Dielectric Properties of Titanates at Ultra-high Frequencies

THE complex permittivity ($\varkappa' - j\varkappa''$) of a series of titanates, magnesium, calcium, strontium and barium, has been measured at 21° C. and frequencies of 1·5 and 9,450 Mc./s., and of the barium titanate at 24,000 Mc./s. also. In addition, the behaviour of barium titanate at 1·5 and 9,450 Mc./s. has been studied over the temperature-range + 20° to + 170° C. The results of these measurements are recorded in the accompanying table and diagram. The electric field-strength applied to the test specimens was estimated as less than 1 volt/cm.



Dielectric properties of barium titanate at 1·5 Mc./sec. and 9,450 Mc./sec. Curves 1, $\varkappa'$ at 1·5 Mc./sec.; 2, $\varkappa'$ at 9,450 Mc./sec.; 3, $\varkappa''$ at 9,450 Mc./sec.; 4, $\varkappa''$ at 1·5 Mc./sec.

The loss tangent ($\tan\delta = \varkappa''/\varkappa'$) of the magnesium, calcium and strontium titanates at 9,450 Mc./s. was sufficiently small to permit the use of a technique, described in an earlier communication[1], which consists in measuring the variation with frequency of the energy transmitted through a slab located in, and filling, the cross-section of a wave-guide. The attenuation in barium titanate, however, proved to be so high that this method could not be used, and the complex permittivity was determined by measurement of the reflexion from and transmission through a slab, at fixed frequency. For the reflexion measurements it was sufficient to consider only the front face of the specimen, since internal reflexions were highly attenuated. In order to reduce the power standing-wave ratio in front of the face to measurable values, quarter-wave 'matching' slabs of lower permittivity materials were used. For example, with 'Tempa *S*', $\varkappa' = 11{\cdot}3$, the power standing-wave ratio was reduced by 320 : 1 and with polystyrene, $\varkappa' = 2{\cdot}56$, by 17 : 1. The attenuation in the material was obtained by measurement of the transmission through specimens with matching slabs at each side. From a combination of the results of the two measurements, values of $\varkappa'$ and $\varkappa''$ can be calculated.

At 21° C.

Material	$\varkappa'$			$\tan\delta = \varkappa''/\varkappa'$		
	1·5 Mc./s.	9,450 Mc./s.	24,000 Mc./s.	1·5 Mc./s.	9,450 Mc./s.	24,000 Mc./s.
$MgTiO_3$	13·0	11·3	—	0·0012	< 0·05	—
$CaTiO_3$	140	132	—	0·0007	< 0·015	—
$SrTiO_3$	264	232	—	0·0009	< 0·03	—
$BaTiO_3$	1,500	300	126	0·015	0·53	0·59

It will be seen from the table that the room-temperature permittivity values at 9,450 Mc./s. of the magnesium, calcium and strontium titanates are not appreciably different from the 1·5 Mc./s. figures, but that for barium titanate a substantial decrease has occurred at the higher frequency, and a still further decrease at 24,000 Mc./s. In keeping with these observations, while the loss tangent of the magnesium, calcium and strontium titanates does not exhibit a particularly marked increase with frequency, that of barium titanate has risen to a very high value at the two ultra-high frequencies. It has not yet been possible to extend the range of frequency measurement, but there can be no doubt of the existence of dispersion in barium titanate in this region of frequency, a fact which will be of considerable significance in the interpretation of its general behaviour.

The variable temperature measurements at 9,450 Mc./s. on barium titanate show that although the permittivity is lower throughout than at 1·5 Mc./s., the rapid rise to a peak value occurs at substantially the same temperature in the two cases.

A full report of the work will appear elsewhere; but I wish to acknowledge here the help afforded by the United Insulator Co. and the Mullard Radio Valve Co. in supplying the ceramic specimens, and to thank the Department of Scientific and Industrial Research for financial support of the work.

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New Photoconductive Cells

So far there are few substances known to possess photoconducting properties with a quantum yield appreciably greater than unity. The chief ones are selenium, oxidized thallous sulphide, and the sulphide, selenide and telluride of lead.

Two questions arise: (1) Are the above-mentioned substances the only possible ones, and, if so, what is the reason for that? (2) What is the role of the oxygen in sensitizing at least thallium and lead sulphides, lead selenide and lead telluride?

Experiments with various types of semi-conductors suggested to me that the particular action of the oxygen can be best accounted for if it is assumed that the oxygen is adsorbed on the semi-conductor particles during evaporation and after the deposit has been formed, and not, or only partly, as a secondary process, taken up by the lattice. It is known that adsorption of gases on finely divided metals is much increased if an electric discharge is passed through the vessel containing the adsorbent[1].

If the above-mentioned view is correct, methods which produce a layer of material by a process in

which an electric discharge is active should yield photoconductive sensitive deposits. Several methods were tried and it was possible to produce highly sensitive cells not only with materials already known to possess photoconductivity, but also with a great number of new substances.

The following methods were used: (1) cathode sputtering with the substance as the cathode; (2) electric discharge between aluminium electrodes and evaporation of the substance from a heater spiral; (3) low-voltage arc with the substance as the anode; (4) a molecular beam of the substance crossing a beam of gas ions before condensing on the carrier. The gas used was oxygen or air and the pressure varied between wide limits depending on the substance ($0{\cdot}5$–10^{-4} mm. mercury).

Using one or the other of the above methods[2], it was possible to produce photoconductive cells of a series of substances which can be divided into two groups. The first group is characterized by the following properties: if the carrier is kept at room temperature or lower during the production, the film has a high resistance, a high negative temperature coefficient of resistance β and has its optimum sensitivity in the near infra-red. Heating the film in air or oxygen afterwards reduces the sensitivity, the resistance and β, and in some instances, for example, platinum, a film with normal metallic properties results. Some substances belonging to this group are platinum, nickel, antimony and germanium.

Substances of the second group have properties similar to those of the first group before heating. Heat treatment of the film in air or oxygen at a low temperature and for very short time reduces the resistance, β, and the sensitivity appreciably; but a prolonged heat treatment at a higher temperature increases the three properties again and, if the conditions are properly chosen, a cell of very high sensitivity may result. The substances investigated up to now and belonging to this group are: the sulphides, selenides and tellurides of lead, tin, indium, thallium, cadmium, bismuth and antimony, and some intermetallic compounds, for example, CdSb. Most of the tellurides show high sensitivity only at $-78°$ C. or at liquid-air temperature. Some of the sulphides are very sensitive even at room temperature.

Although the general behaviour of all the deposits produced up to now is similar, there are very wide variations in the absolute values of the resistance, β, the sensitivity, and the spectral distribution of sensitivity for even the same substance, depending on the conditions of production and on the following heat treatment. The properties of a layer of indium telluride are given as an example to indicate this general behaviour. Evaporation of the substance was carried out according to method 3 in air ($p = 0{\cdot}05$ mm. mercury) and the deposit formed on a glass strip, fixed at 40 mm. distance from the source and cooled by running tap water. The deposit thus formed after several seconds was just transparent and brown in transmission. The resistance of a sensitive area of 4 mm. length and 1 mm. width was of the order of 250 megohms at room temperature. The sensitivity for visible light and the near infra-red was very low and β was negative. Heating the layer in air to approximately 100° C. for 2 min. reduced the resistance to 0·3 megohms. Further heating in air at 160° C. for 15 min. produced a resistance of 2·4 megohms at room temperature and the sensitivity increased manifold. At liquid-air temperature the resistance was 120 megohms, and the cell was superior in performance to a Schwarz–Hilger vacuum thermopile as far as $2{\cdot}2\,\mu$.

It is common to all the cells, with the exception of thallium sulphide and of selenide, that they are stable in air. It is easily possible to produce cells of any size and shape and, as a great number of cells can be produced at the same time, the uniformity and reproducibility are very good. The colour in transmission of most sensitive cells is brown to red-brown, indicating that this property is not so much dependent on the special substance as on a specific arrangement and size of the deposited particles, which must be similar in all cases.

The primary condition which must be fulfilled to produce a sensitive layer is that β should be negative; this depends on the gas pressure, the length of the path the evaporated particle travels before it reaches the carrier and the electrical conditions of the discharge.

If dissociation of the substance is too high, the metallic part of the compound is evaporated first by one of the above methods and this metal deposit afterwards transformed into the compound by heating it in an evacuated tube and passing a stream of the other constituent over it. With this method it was possible to produce, for example, photoconductive sensitive cells of silver sulphide, selenide and telluride.

The theoretical implication of these discoveries and a full description of the experimental results will be given elsewhere.

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[1] Pietsch, *Ergeb. exakt. Naturw.*, **5**, 212 (1926).
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Hydrogen Peroxide and the Indirect Effect of Ionizing Radiations

In a recent paper, Allsopp[1] has suggested that the old 'poison' hypothesis for the action of ionizing radiation on living cells might be revived in terms of the 'hydroxyl radical' as the specific poison. Results of experiments on bacteriophage *S*13, undertaken at the instigation and with the support of the late Dr. D. E. Lea, suggest that for certain *in vitro* experiments, at least, on the indirect effects of ionizing radiation, a poison hypothesis in quite direct terms will explain the results satisfactorily, the specific poison being hydrogen peroxide. As has been pointed out[2], the fact that hydrogen peroxide is formed in irradiated water itself requires explanation in terms of a theory such as that of Weiss[3]; but it has become evident that all the observed facts on 'indirect' action of radiation on this particular phage are fitted by the explanation that when the phage is in dilute solution the hydrogen peroxide formed by ionizing radiations will inactivate it. The following results support this explanation.

(1) Tests with titanium sulphate show that the quantity of hydrogen peroxide produced when the phage is in dilute solution is of the expected order of magnitude[4].

(2) Survival curves for the phage irradiated in dilute solution were sigmoid; that is to say, the rate of inactivation increased with increasing dose

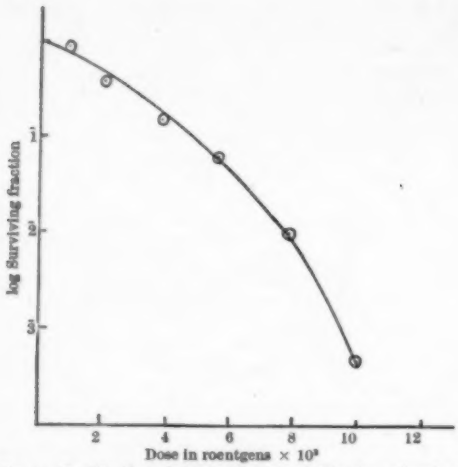

Fig. 1. Inactivation of phage *S*13 suspended in clean phosphate buffer. Composite curve, three experiments

(Fig. 1). When the buffer in which the phage was suspended had received a previous irradiation of some hundred thousand roentgens, however, the survival curve was exponential (Fig. 2), indicating that such a curve is obtained after the quantity of hydrogen peroxide in the solution has reached an equilibrium, or at any rate a minimum value.

(3) Disinfection experiments using a quantity of hydrogen peroxide of the same order as that formed in the suspension in the irradiation experiments yielded the usual form of exponential disinfection curve.

(4) A temperature effect was discovered in the irradiation experiments, the rate of inactivation being lower at lower temperatures. This is not easily explained on the 'active radical' hypothesis, but fits in with the well-known temperature effect in any disinfection process.

(5) The increase in activation dose with increasing concentration was found to be analogous with that found in other virus experiments[5,6]. The addition of protein to a dilute solution was found to protect the phage in irradiation experiments. In hydrogen peroxide disinfection experiments, similar results are obtained; for example, the addition of 5 per cent peptone to a dilute phage solution in the irradiation experiments fully protected the phage, so that the inactivation dose equalled that required for a dry phage suspension. The same percentage of peptone protected the phage fully against the hydrogen peroxide in concentrations which inactivated the phage rapidly when suspended in buffer free from organic material. Here again is the usual action of organic material in protecting organisms against disinfection by an oxidizing agent.

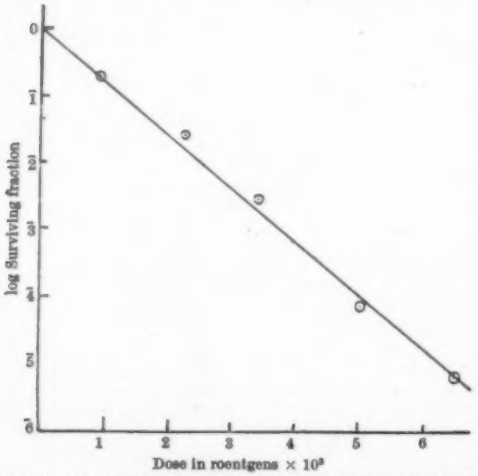

Fig. 2. Inactivation of phage *S*13 suspended in pre-irradiated buffer. Composite curve, three experiments

In experiments on 'indirect effect' of ionizing radiations, the ratio of ionic yield for direct action only to ionic yield in dilute solution is of importance for gaining an insight into the 'active radical' mechanism. It is clear that where the experimental material is in any way sensitive to hydrogen peroxide, this ratio may, in fact, be yielding information only on the production of hydrogen peroxide.

This work was begun at the Strangeways Research Laboratory, Cambridge, and continued in the Medical Research Council Radiotherapeutic Research Unit, Hammersmith Hospital, London, and at the Onderstepoort Laboratories, Transvaal. I have to acknowledge with gratitude the kind hospitality of all three institutions and the interest and assistance of Dr. F. G. Spear of the Strangeways Research Laboratory. The work was started as part of the experimental programme of the late Dr. D. E. Lea, and was continued with the support and constant advice of Dr. L. H. Gray.

The results will be more fully published elsewhere.

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Air-Cored Synchrotron

THE air-cored synchrotron[1,2] appears to have a number of very attractive features, especially if only infrequent pulse operation is required, say, for cloud-chamber experiments, for in such a case the condensers provided to store the magnetic field energy can store perhaps twice as much as when used on alternating current. If, in addition, it proves possible to hold the electrons to a very narrow region so that the guide field is used efficiently, then energies in the 500-MeV. region seem attainable with condenser banks already available in physical laboratories. The upper limit of energy is then set by the deformation of the conductors under the mechanical forces, so that the total impulse becomes the relevant quantity. Thus it is important to use rapidly rising magnetic fields, and a condenser-coil system either nearly critically damped or incorporating a rectifier, so that a slowly damped train of oscillations do not add unnecessarily to the impulse handed on to the coil system. We are pursuing experiments which indicate that im-

pulsive forces greatly in excess of the static ultimate strengths of the coil materials can be withstood.

Particle accelerators of the synchrotron (and cyclotron) type are characterized by the fact that of the three fundamental quantities H (magnetic field), r (orbit radius) and f (frequency of accelerating electric field), two in general must vary during the acceleration. The exceptions are for the extreme cases of non-relativistic particles (cyclotron acceleration, r only varies) and extreme relativistic particles (synchrotron acceleration, H only varies).

The acceleration of electrons from relatively low energies to extreme relativistic energies by conventional synchrotron techniques may be accomplished in two ways: either the frequency of the electric field may be kept constant and the equilibrium radius allowed to vary, or the radius may be kept constant and frequency modulation employed.

The first of these is excluded when we wish to keep the guide-field energy low, and the second does not seem to have been adopted, doubtless due to the technical difficulties of frequency modulating. These difficulties are made worse for air-cored machines, where for the reasons given the modulation would have to take place rapidly.

Betatron acceleration for bringing the electrons up to relativistic energies as in conventional iron-cored synchrotrons is also possible, but unattractive, since it is extravagant in condensers and furthermore the central betatron flux must be steered away from the guide-field region, a difficult problem in coil design.

The object of this communication is to propose a method of bringing the electrons up to the relativistic region, which while generally applicable may be specially attractive for an air-cored machine, since the radial drift of the electrons is limited, the exciting oscillator frequency is constant, and the effect is obtained by blanking off the oscillator at appropriate moments.

The principle of this method is to make the frequency of the accelerating radio-frequency field an integral multiple, ν, of the frequency of revolution of the electrons at injection, which takes place at the inside of the doughnut. If the injection voltage is sufficiently high, a synchronous beam will be obtained, individual electrons oscillating about an equilibrium orbit which expands as the magnetic guide-field is increased. This expansion is allowed to proceed until the electron energy is such that if it were at the inside of the doughnut its frequency of rotation would be $1/(\nu - 1)$ times that of the applied electric field, which is then suppressed until the equilibrium orbit shrinks to the inside. The radio-frequency field is reapplied, and this sequence is repeated until the electron energy reaches the extreme relativistic region, when the machine becomes identical with the conventional synchrotron, except that the applied radio-frequency will still be some multiple (less than ν) of the frequency of electron rotation. The greater the number of expansions and contractions (that is, the larger ν), the smaller the range of variation of the orbital radius during acceleration and thus the greater the machine efficiency from the point of view of energy storage.

To obtain adequate injection efficiency, the radio-frequency voltage must be sufficient to give a fairly large initial amplitude (Δr) of the radial oscillation corresponding to the phase oscillations of the electrons, so that one fills an annulus of width $2\ \Delta r$. Subject to this condition, one finds in practice that the range of phase stability extends over a large fraction of the radio-frequency cycle.

The theory of Bohm and Foldy[3] enables us to determine the fraction of electrons accepted at each expansion, assuming the radio-frequency amplitude builds up instantaneously, and for the machine detailed below this would average about 70 per cent, that is, an overall loss of 50 per cent for the two expansions. By suppressing the radio-frequency oscillator of a normal synchrotron for various time intervals and observing the effect on gamma-ray output, we find that the efficiency of electron capture can approach 100 per cent. This favourable correction can be explained by taking into account the build-up of the oscillations in the synchrotron resonator after a period of suppression.

We are indebted to Mr. D. W. Fry (Atomic Energy Research Establishment, Malvern) for the use of the 15-MeV. synchrotron for these experiments, which will be reported elsewhere.

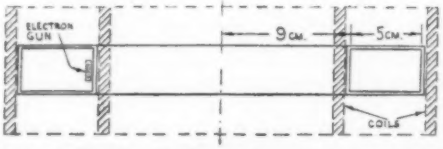

Fig. 1. Doughnut cross-section, with a possible coil arrangement shown dashed and shaded

The calculations for a small machine of this kind on the scale of Fig. 1 are given in the accompanying table with $f = 1{,}200$ mc./s., $\nu = 5$, and H varying as $1/r^{0.5}$.

	Equilibrium radius	Energy	H (at $\Delta = 10$ cm.)	Δr
Beginning of 1st expansion	9·95 cm.	0·080 MeV.	99 gauss	0·50 cm.
End of 1st expansion	12·43	0·148	123	
Beginning of 2nd expansion	9·95	0·148	138	0·40 cm.
End of 2nd expansion	13·28	0·430	228	
Beginning of 3rd expansion	9·95	0·430	263	0·25 cm.
End of 3rd expansion	11·92	—	—	

The sequence of events is also illustrated by Fig. 2, assuming that $dH/dt = 2{\cdot}5$ gauss/microsecond.

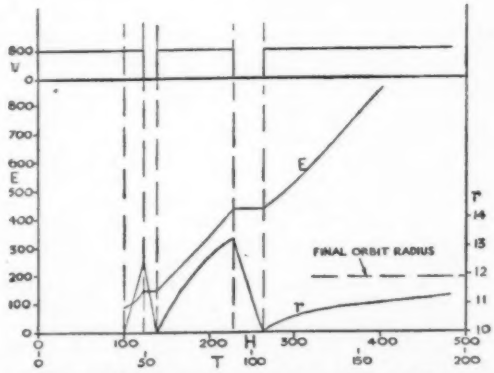

Fig. 2. Variation of resonator voltage V, equilibrium orbit radius r cm., and particle energy E keV., with magnetic field H gauss at 10 cm. radius and time T microseconds. Injection occurs at $H = 100$, $E = 80$ keV.

For a peak resonator voltage of about 800 volts, the range of stability in phase is about 340°, with an associated radial oscillation of amplitude given by Δr in the table.

Taking an intermediate estimate for the ratio of magnetic energy in working volume to total condenser energy as 1/3, we find that 10,000 joules stored energy will produce 85 MeV. electrons with a peak force on the coil of the order of 500 lb./in.[3] directed away from the accelerating region.

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Renal Regulation of the Extracellular Fluid

The behaviour of the kidney in relation to the electrolytes of the extracellular fluid is usually described in terms of two mechanisms operating to maintain the homœostatic state: (*a*) Regulation of the concentration of several individual electrolytes and non-electrolytes within a limited range of variability. The concept of 'renal threshold' is implied in this proposition. (*b*) Regulation of the osmotic pressure of the extracellular fluid, so as to maintain isotonicity with intracellular fluid.

A patient with a duodenal fistula was studied in some detail. He lost up to the equivalent of one quarter of the extracellular fluid of the body each day. The fluid from the fistula contained an average of 121 milli-equiv. per litre of sodium and 55 milli-equiv. per litre of chlorine. Thus there was an excess of 66 milli-equiv. per litre of sodium relative to chloride. In these circumstances, the level of sodium in the extracellular fluid would tend to fall by a greater amount per unit time than the chlorine, and the loss of this alkaline secretion would impose a severe strain on the *p*H control of the extracellular fluid.

The following observations were made: (*a*) Large amounts of chloride were present in the urine over a period of six weeks, during which time the level of chloride in the plasma was constantly below the accepted 'renal threshold'. (*b*) There appeared to be a commensurate variation between the quantity of chloride ion in the urine, and the volume of fistula secretion per day. (*c*) On the thirty-sixth day after the development of the fistula, the blood sodium and alkali reserve were restored to within normal limits by the intravenous administration of two-thirds of a gram molecule of sodium lactate, over a twelve-hour period. This caused a cessation of the large chloride excretion by the kidney. When the blood sodium fell again the chloride excretion recommenced. Over the time interval during which these variations occurred, the plasma chloride remained relatively constant at a level below the 'renal threshold'.

The most interesting feature of the findings was the relative constancy of the ratio of chlorine to sodium in the extracellular fluid, despite the continued loss through the fistula and from the body of 2–4 litres per diem of fluid containing approximately twice as much sodium as chloride. On the thirty-seventh day after the development of the fistula plasma, values were Cl = 82·7 and Na = 148·7 milli-equiv. per litre with the ratio $Cl_p/Na_p = 0{\cdot}56$. Over the following six days 11·5 litres of fluid containing 766 milli-equiv. of sodium in excess of chloride were lost from the fistula. This is equivalent to 766/14 = 55 milli-equiv. of Na per litre of extracellular fluid, assuming this latter to have a volume of approximately 14 litres[1]. However, the ratio was $Cl_p/Na_p = 80/138{\cdot}3 = 0{\cdot}58$ at the end of the period. The probable explanation was the excretion by the kidney of fluid containing a sufficient excess of chlorine over sodium to maintain homœostasis. The cation used in this latter mechanism was predominantly potassium from intracellular fluid.

It would therefore seem possible that to account for the factors affecting the renal regulation of the quantity per unit volume of extracellular ions, it is necessary to consider plasma *p*H as a major variable.

It has become apparent that the maintenance of the equilibrium state within the tissue fluids in circumstances of disease is a basic problem of medical practice. Marriott, in the Croonian Lectures[2], has suggested that the quantity of chloride in the urine, as determined clinically by the simple Fantus test[3], can be used as a diagnostic criterion of the presence or absence of chloride depletion in the extracellular fluid. A correlation of the above observations with clinical phenomena to be described elsewhere would indicate the necessity of an experimental investigation to determine in what clinical circumstances the test is valid. It is suggested that the logical first step in clinical practice of ionic replacement therapy is qualitative analysis and quantitative record of the material which the body is losing.

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Isophosphorylase and the Formation of Branched Polysaccharides

The combined action of isophosphorylase and phosphorylase on glucose-1-phosphate results in the formation of branched polysaccharides like amylopectin and glycogen. Isophosphorylase is the enzyme which catalyses the formation of α-1,6-glucosidic links from glucose-1-phosphate as well as their phosphorolysis[1].

Whereas phosphorylase obtained from potato, yeast or muscle is strongly inhibited by phlorhizin, we have established that isophosphorylase from potato or yeast does not suffer any diminution in activity in the presence of phlorhizin (see table).

By adding phlorhizin to a mixture of phosphorylase and isophosphorylase, the activity of the former enzyme is diminished but not that of the latter.

Effect of phlorhizin on the action of potato isophosphorylase (phosphate buffer *p*H 6·6)

Concentration of phlorhizin	Degradation of residual dextrin by β-amylase	
	Isophosphorylase present	Isophosphorylase absent
0	25 per cent	0 per cent
$6{\cdot}0 \times 10^{-2}$ mol.	25 ,,	0 ,,

Thus the addition of phlorhizin brings about a change in the relative effective amounts of the two enzymes.

By allowing a mixture of potato phosphorylase and potato isophosphorylase to act on glucose-1-phosphate in the presence of increasing amounts of phlorhizin, we have obtained a series of polysaccharides which give with iodine a range of coloration from blue-violet, violet, purple to brown, that is to say, which have increasing degrees of branching, ranging from that of amylopectin to that of glycogen.

The degree of branching of the polysaccharide obtained by the combined action of phosphorylase and isophosphorylase depends, therefore, on the proportion of the two enzymes. The larger the relative amount of isophosphorylase the more branched is the polysaccharide formed.

We wish to thank Prof. K. H. Meyer for his interest in this investigation.

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Microbiological Oxidation of Sterols

In a previous communication[1], we described a method by which we oxidized cholesterol with *Azotobacter*. Our present experiments had a double purpose: (1) to limit the direction of the oxidation as narrowly as possible; (2) to work out a simple reproduction method, for our *Azotobacter* react with extreme sensitivity to antagonistic bacteria, so that their culture can be made only under the strictest sterile conditions.

For this double purpose we used bacteria which grow selectively on a certain medium, and investigated bacteria which decompose pyridine. We found that for oxidation of cholesterol *Proactinomyces roseus* was the most suitable[2]. This bacterium simultaneously decomposes the pyridine most effectively, and in the presence of a source of carbon multiplies fairly intensively. The presence of pyridine prevents the growth of other bacteria in the culture, so we could always carry out these experiments without any special sterilization. If we used cholesterol as source of carbon in the pyridine medium and aerated it for a suitable time, oxidation occurred and 7-oxycholesterol and cholestenone formed as oxidation products.

The formation of 7-oxycholesterol means that in the sterol series the $-CH_2-$ group can be oxidized to alcohol bacteriologically. As under suitably selected experimental conditions principally 7-oxycholesterol is formed, the results have a practical significance for the manufacture of the 'D_3' provitamin, as we succeed in obtaining it from cholesterol in very good yield in one step.

The experiments were made under the following conditions. We dispersed 0·5 gm. cholesterol in a litre of 0·2 per cent pyridine synthetic culture, and inoculated the mixture with *Proactinomyces roseus*. The culture was kept 14 days in a thermostat at 34° C. with constant aeration, and the pyridine used up was replaced from time to time. At the end of the cultivation period we extracted the medium with petrol-ether. The products were separated by chromatographic absorption on aluminium oxide. Besides the remaining minimal cholesterol we isolated as chief product 7-oxycholesterol and 4,5-cholestenone. Other oxidation products also formed in minimal quantities, identification of which is now in progress. We are continuing these experiments with *Proactinomyces roseus* in the sexual hormone series.

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The Sommelet Reaction

In a recent communication, Angyal and Rassack[1] show that the Sommelet reaction[2] is an oxidation-reduction process with the aldimine Ph.CH=NH as a probable intermediate,

$$PhCH_2NH_2 + PhCH_2N:CH_2 \xrightarrow{H_2O} PhCHO + NH_3 + PhCH_2NHCH_3,$$

and does not involve, as originally suggested by Sommelet[2], and stated by Graymore and Davies[3], prototropic conversion of methylenebenzylamine (I) to benzylidenemethylamine (II).

$$(I)\quad Ph.CH_2 - N = CH_2 \rightleftharpoons \left[Ph.CH \overset{\frown}{-} N - CH_2\right]^- \rightleftharpoons Ph.CH = N - CH_3 \quad (II)$$

It is desirable to point out that this mechanism, now disproved, was inherently improbable. Ingold and Shoppee[4] showed that the methyleneazomethine system is one of the least mobile of triad prototropic systems; mobility in the phenylmethylene-azomethine system (I—II) is only achieved in the catalytic presence of hydroxide ions at 300° or of a considerable concentration of ethoxide ions at 190°, 2·92 *N*-sodium ethoxide in ethanol at ~ 85° being ineffective. These results were considered by Graymore and Davies, who, however, dismissed them with the remark that they are not comparable with those obtained by them in the presence of hexamine in dilute aqueous solution (boiling approx. 0·3 *N*-hydrochloric acid), and who state that under these conditions isomerization of methylenebenzylamine (I) to benzylidenemethylamine (II) ensues. While suitable prototropic systems are capable of catalysis by acids, methylenebenzylamine (I), like other Schiff's bases, is readily hydrolysed by hot dilute mineral acid[4]; even if, owing to the presence of an excess of formaldehyde, some proportion of methylenebenzylamine is always present under the experimental conditions used by Graymore and Davies, facile catalysis of a prototropic system so refractory as (I — II) under these conditions seems in the highest degree unlikely.

Graymore and Davies also suggest that the conversion of only some 10 per cent of methylenebenzylamine (I) to benzylidenemethylamine (II) in the presence of catalytic anions, reported by Ingold and Shoppee, is due to the removal of methylenebenzylamine (I) from the reaction by polymerization. It seems more probable that the proportion of isomerides, (I) 90 per cent : (II) 10 per cent, observed experimentally, is an example of the kinetic control of ion-recombination as opposed to the thermo-

dynamic control of equilibrium, which is frequently encountered in prototropy and generally leads to the production of more than the equilibrium proportion of the thermodynamically less stable isomeride[5]. Owing to conjugation of the phenyl group with the double bond in (II) but not in (I), (II) is thermodynamically the more stable isomeride since the conjugation energy will contribute to its free energy. Neglecting other factors of a constitutional or environmental character, and taking the conjugation energy of the system Ph—CH=N· (for which no value appears to be available) as closely similar to that of the system Ph—CH=CH· (7 kilocal.)[6], it can be calculated using the relation $-\Delta F = RT \log K$ that the equilibrium proportion of (I) is about 0·005 per cent at 358° K., 0·008 per cent at 373° K., 0·03 per cent at 463° K. and 0·2 per cent at 573° K.; and, in fact, both at 190° and 300° C. the proportion of methylenebenzylamine (I) was too small for experimental detection[4].

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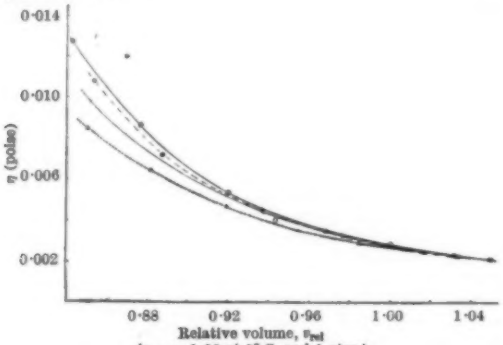
Viscosity-Volume Relation for Ether

It has recently been shown[1] that the theoretical expression for the viscosity of a liquid derived from Born and Green's[2] general kinetic theory of liquids consists of two parts, one due to the thermal motion of the molecules and the other to molecular attraction (that is, a volume effect). The latter effect greatly predominates.



○——○, 0° C.; ●····●, 20° C.; ×——×, 30° C.; ▲····▲, 75° C.

Experimental justification for this conclusion is provided by the accompanying isothermal viscosity-volume curves, calculated for ether, from the combined data of Bridgman[3] and Faust[4] on viscosities at high pressures. The temperature effect becomes progressively less as the volume increases until, in the region $v_{rel} = 1{\cdot}0$, it disappears completely. To the right of this point, the viscosity is a function of volume alone and is independent of temperature, and it is in this region that the empirical equation proposed by Batschinski[5],

$$\eta = \frac{c}{v - \omega},$$

where c and ω are constants and v is the specific volume, is so successful in representing observed behaviour.

Certainly in the case of ether above 0° C. therefore, and probably for many other liquids, the decrease in viscosity on heating at atmospheric pressure is a secondary effect, due entirely to expansion of the volume which in turn lowers the viscosity.

This is precisely the early view of the mechanism of the temperature variation of viscosity, first propounded by Warburg and von Babo[6] in 1882, and since then by many other authors, notably Batschinski (*loc. cit.*), which is now seen to be quite correct over the limited experimental range for which evidence was then available.

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British Species of *Polycelis* (Platyhelminthes)

In 1884 Ijima[1] described *Polycelis tenuis* Ijima, a species which closely resembled the well-known *P. nigra* Ehrbg. More recently, interest in the legitimacy of this species has been shown by Continental workers, particularly Komarek[2] and Sekera[3]. These two authors agreed that both *P. nigra* and *P. tenuis* are good species; but they differed on the external features whereby the species might be distinguished. Lender[4] concluded that they could only be distinguished on the basis of internal anatomy and discounts such differences as shape of head, number of eyes and colour; he also regarded them as ecologically similar. Latterly, Tu[5] has questioned their separation as true species, but, like Lender, he found them in the same habitat on the Continent.

There is no mention in British literature of *P. tenuis*, all records referring to *P. nigra* or the distinctive *P. cornuta*. While studying the ecology of *Urceolaria* spp. (Peritricha) living on flat-worms[6], an apparent colour variety was noted which either carried few *Urceolaria mitra* v. Sieb. or none. This variety was distinguished by the much more uniform distribution of pigment compared with other worms in which the darker pigment occurred in blotches; that is, there was a pattern difference. Both types showed the usual colour range from yellow through brown to black. Fig. 1 records the population of *U. mitra* found on these two colour patterns—the uniform variety averaged 0·7 *Urceolaria* per worm, while the mottled variety averaged 22.

Examination of the reproductive organs of these two types showed that those with the uniform colour pattern agreed with *P. nigra*, whereas those with the mottling agreed with *P. tenuis*. These anatomical differences are quite marked[2,3,4] and relate to the shape of the penis, the type of spines carried on it and the presence or absence of musculo-gland organs. Fig. 2*a* shows the elongated penis of *P. tenuis* with about twenty rows of spines, mostly of a simple type

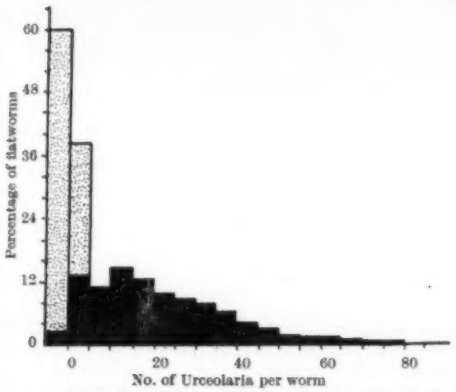

Fig. 1. Comparison of the Urceolarian population of the uniform (stippled) and mottled (black) varieties of flatworm

(Fig. 2*b*), Fig. 2*c* the shorter penis of *P. nigra* with four to eight rows of compound spines (Fig. 2*d*). The former has two musculo-gland organs. The worms referred to were taken from the College pond where the population of *P. nigra* is small compared with *P. tenuis*, in ratio about 1 to 28. The presence of *P. tenuis* has also been confirmed in a sample of flatworms from Lake Windermere kindly sent by Dr. T. T. Macan. Of 17 worms examined, 13 were *P. tenuis* and 4 *P. nigra*.

The discrimination shown by *Urceolaria mitra* suggests that the physiology and perhaps the ecology of the two flatworms differs. This is borne out by their distribution in the pond and behaviour in the laboratory. *P. nigra* occurs most abundantly near the inlet to the pond where the water moves slowly; *P. tenuis* prefers regions where the water is still. This is supported by examination of other habitats; for example, *P. nigra* occurs alone in a stream at Aber below the zone of *P. cornuta*. There may also be differences in the type of pond the two species favour, but overlap occurs. In the laboratory under conditions resembling a pond habitat rather than a stream, *P. tenuis* thrives much more than *P. nigra* and produces cocoons more freely.

P. nigra has been a favourite type for physiological work, and also figures in many ecological surveys. It is conjectural to what extent it has been confused with *P. tenuis* in the past, in Great Britain, and how this may have affected conclusions. If, as I suggest, the two species can be distinguished on colour pattern, then they can be easily separated under the binocular microscope. This only becomes difficult when the worms have fed heavily and are distended.

T. B. Reynoldson

Zoology Department,
University College of North Wales,
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June 4.

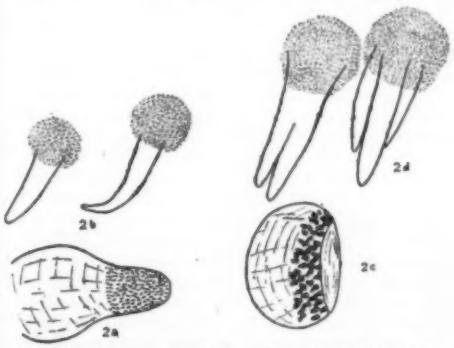

Fig. 2. Comparison of the penis and typical penial spines of *Polycelis tenuis* (*a*, *b*) and *P. nigra* (*c*, *d*)

[1] Ijima, J., *Z. Wiss. Zool.*, **40**, 359 (1884).
[2] Komarek, J., *Zool. Anz.*, **70**, 70 (1926).
[3] Sekera, E., *Zool. Anz.*, **72**, 91 (1927).
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Determination of Plant Densities

E. J. Machin[1] appears to be unaware of the extensive study by G. E. Blackman[2] on the relation between plant density and percentage absence. In a theoretical appendix to this paper, I have pointed out that the most efficient size of quadrat corresponds to about 20 per cent absence, or a product of quadrat size and plant density of about 1·6 (the efficiency remains reasonable over a range of, say, 0·7–3·0, compared with the rather wider range 0·3–3·3 implied by Machin).

It should also be noted that, while the method is only applicable as an exact method when the distribution of plants is random, it may be used in the more general class of cases for which the relationship between the logarithm of percentage absence and plant density is still linear to provide a comparative index of abundance.

M. S. Bartlett

Department of Mathematics,
University of Manchester.
Aug. 24.

[1] *Nature*, **162**, 257 (1948).
[2] *Ann. Bot.*, **49**, 749 (1935).

Groundnut Breeding

In view of the increasing economic importance of the groundnut, a new investigation of its chromosomes should be made known at once. Mendes[1] reports from São Paulo that *Arachis diogii*, *A. marginata*, *A. prostrata*, and a cultivated form from the Mato Grosso, all have 20 chromosomes, the previously known species and cultivated forms[2] all having had 40. Evidently the cultivated forms are mostly tetraploid, and their diploid ancestors are now revealed to us for the first time. The tetraploidy of the groundnut may well have arisen at an early stage of its peregrination when it passed from Brazil to Peru in pre-Columbian times[3].

The diploid species now offer us a ready means of protecting our very vulnerable groundnut industry from disease if we are willing to enrich the store of available variation in this hitherto unresponsive crop by crossing with the new wild sources.

C. D. Darlington

John Innes Horticultural Institution,
London, S.W.19.
Sept. 28.

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ANTI-TUBERCULAR ACTIVITY OF OXIDATION PRODUCTS OF SUBSTITUTED *o*-PHENYLENE DIAMINES

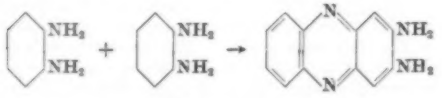
By Dr. VINCENT C. BARRY, J. G. BELTON, M. L. CONALTY and D. TWOMEY

Department of Chemistry, University College, Dublin, and School of Pathology, Trinity College, Dublin

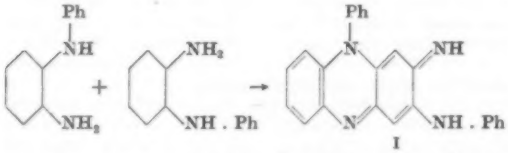
As reported in an earlier communication in *Nature*, we have been examining the anti-tubercular properties of substituted diphenyl ethers and related compounds[1]. In extending this study to include diphenylamine derivatives, a curious phenomenon was encountered with 2-aminodiphenylamine. When freshly prepared, an aqueous solution of the hydrochloride of this base completely inhibits the growth of *Myco. smegmatis* at a dilution of 1/100,000. On keeping, and occasional warming, the inhibitory power of this solution increases gradually, the five weeks old solution producing complete inhibition at a dilution of 1/1,000,000. At the same time it was noticed that the colour of the solution rapidly changed from an initial pink to a very dark red. The highly coloured product formed in the solution was obviously of great interest. It was afterwards found that addition of ferric chloride solution to an acid solution of the base produced an immediate deep red coloration and separation of a dark crystalline precipitate. This proved to be the hydrochloride of a base, $C_{24}H_{18}N_4$, from which the base itself was liberated by ammonia in the form of a brick-red crystalline powder.

When tested in broth against *Myco. smegmatis* and *Myco. tuberculosis* (*H37Rv*), the dye salt proved to have a remarkable biological activity. Complete inhibition of growth of the former for six days is produced at a dilution of 1/1,500,000 and of the latter for 42 days at 1/20,000,000. The activity is retained to a considerable extent in the presence of five per cent pooled human serum.

A subsequent search of the literature showed that the rapid acquisition of a red colour by solutions of 2-aminodiphenylamine salts had been noted frequently, and a number of workers had investigated the oxidation of this aromatic base with ferric chloride[2–6]. Kehrmann[2] showed that the oxidation of *o*-phenylenediamine with ferric chloride yielded 2 : 3-diaminophenazine, the formation of which he explained as shown :



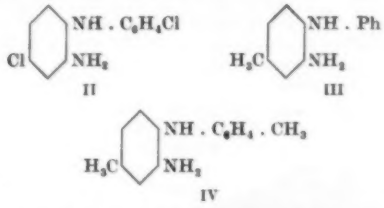
Fischer and Dischinger[3] maintained that the oxidation of 2-aminodiphenylamine followed on the same lines.



I

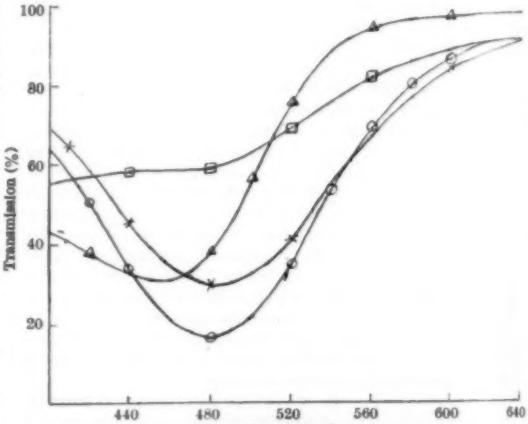
Analyses and molecular weight determinations of (I) as prepared by us agree with the above formula.

With the view of confirming the mechanism of the oxidation as outlined above, 2-aminodiphenylamine derivatives carrying a substituent in the aminated ring in the position *para* to the NH— bridge were oxidized under similar conditions.



II III IV

(II) gave a pigment showing similar colour reactions to (I), and on analysis proved to have lost one chlorine atom in four during the oxidation. This compound could only have formed a pigment of this type by loss of chlorine. (III) and (IV), containing stable *para* substituents, gave highly coloured products also ; but these showed different colour reactions and absorption curves, and had low antitubercular activity. They clearly belong to a different class from (I) and constitute further evidence in favour of Fischer's formulation.

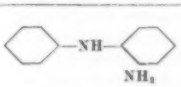
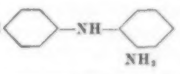
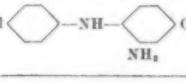
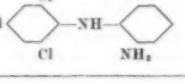
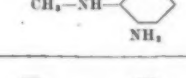
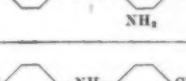
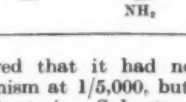


Pigments from : ○, 2-aminodiphenylamine ; ×, 4 : 4′-dichloro-2-amino-diphenylamine ; □, 4-methyl-2-aminodiphenylamine ; △, N-methyl-*o*-phenylene diamine

Further pigments were prepared from mono-, di- and tri-chlorinated 2-aminodiphenylamines, the chlorine atoms being substituted in the ring not carrying the —NH_2 group. As expected, these were very highly coloured, and their absorption curves and the colour exhibited by them in strong mineral acid resembled closely that of (I). As seen in Table 1, however, the antibacterial activity is low when the molecule contains more than two chlorine atoms. The loss of activity in these molecules may be due to alteration in the lipoid/water solubility ratio consequent on the higher degree of halogenation.

When (I) was given in the feed to guinea pigs experimentally infected with tuberculosis (Ravenel *Rv* strain), at a dosage of 33 mgm. per day, it had no effect on the course of the infection. None of the pigment was excreted in the fæces of these animals, and it is possible that it was decolorized by the intestinal flora. *In vitro* tests with (I) against *B. coli*

Table 1. The numbers represent the dilutions which cause complete inhibition of *Myco. smegmatis* for 6 days and *Myco. tuberculosis* for 42 days

Pigment from	*Myco. smegmatis*	*Myco. tuberculosis*	
		Without serum	With 5 per cent serum
	1,500,000	20,000,000	3,000,000
	2,000,000	3,000,000	2,000,000
	20,000	25,000	—
	5,000	50,000	—
	200,000	2,000,000	1,000,000
	5,000	300,000	50,000
	5,000	50,000	50,000

showed that it had no inhibitory effect on this organism at 1/5,000, but that it was decolorized by the bacteria. Subcutaneous or intramuscular injection of the hydrochloride of (I) in guinea pigs in doses of 5–35 mgm. produced severe local toxicity, and this mode of administration could not be continued. Intravenous injection in rabbits proved rapidly fatal. When 2-aminodiphenylamine hydrochloride is oxidized by ferric chloride in the presence of human serum, a very deep red pigment is formed which does not separate. Menkin[10,11] has successfully administered ferric chloride intravenously. In view of this and in the hope that the toxic effect might be reduced if the pigment were produced in the blood stream, rabbits were injected intravenously with 2-aminodiphenylamine (15 mgm., 2 c.c.), followed by ferric chloride (15 mgm., 6 c.c.). The rabbits died, however, after an average total quantity of 100 mgm. of 2-aminodiphenylamine had been given over a period of fourteen days, a quantity comparable to the amount of (I) which had already proved lethal intravenously.

Table 2. Antibacterial activity of the pigment (I) from 2-aminodiphenylamine. The figures given in the third and fourth columns represent the dilutions which cause complete inhibition of growth

Organism	Period of growth (days)	Inhibitory dilution in broth	Inhibitory dilution in broth + 5 per cent human serum
Myco. tuberculosis	42	20,000,000	3,000,000
Myco. smegmatis	6	1,500,000	1,500,000
Corynebacterium diphtheriæ (mitis)	3	7,500,000	60,000
Staph. aureus	3	200,000	<60,000
Strep. fæcalis	3	100,000	10,000
Strep. pyogenes	3	200,000	<60,000
Strep. viridans	3	80,000	20,000
Vibrio 10	3	10,000	10,000
B. typhosus	3	80,000	5,000
Bact. coli	3	<5,000	—

While it is clear that the high toxicity of (I) for animals renders it unsuitable for therapeutic use, it may be possible to reduce the toxicity of this structure without destroying its antibacterial power. This might be achieved by increasing the solubility of the pigments by including an OH, COOH or similar group in (I), or alternatively by synthesizing pigments of lower molecular weight. The pigment produced from N-methyl-*o*-phenylene diamine (Table 1) has very high activity against the tubercle bacillus, and its toxicity to animals should be lower than that of (I). These alternatives are being investigated.

These synthetic pigments are of added interest because of their relation to the bacterial pigments, pyocyanine, chlororaphin and iodinin, all of which are phenazine derivatives. Also Iland has reported recently on the high antitubercular activity *in vitro* of N-oxides of phenazine[12].

This investigation is being conducted and financed by the Medical Research Council of Ireland, to which grateful acknowledgment is made. The strains of *Myco. tuberculosis* used in these experiments were provided by the Trudeau Foundation. Our thanks are due to Mrs. E. Philbin for assistance.

[1] Barry, V. C., O'Rourke, L., and Twomey, D., *Nature*, **160**, 800 (1947).
[2] Fischer, O., and Seeder, L., *Berichte*, **22**, 3798 (1889).
[3] Schöpff, M., *Berichte*, **23**, 1839 (1890).
[4] Ernst, O., *Berichte*, **23**, 3426 (1890).
[5] Kehrmann, F., and Messinger, J., *J. Prākt. Chem.*, **46**, 568 (1892).
[6] Fischer, O., and Heller, O., *Berichte*, **26**, 378 (1893).
[7] Kehrmann, F., *Berichte*, **28**, 1709 (1895).
[8] Fischer, O., and Dischinger, A., *Berichte*, **29**, 1602 (1896).
[9] Kehrmann, F., *Berichte*, **22**, 1983 (1889).
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TENTH INTERNATIONAL LIMNOLOGICAL CONGRESS, ZURICH

THE International Association for Theoretical and Applied Limnology, the object of which is to provide a common meeting ground for those interested in the biology and utilization of fresh waters, achieves its purpose by means of congresses which are ordinarily held every two years and the proceedings of which are afterwards published. Between successive congresses, matters requiring attention are dealt with by the president, the secretary and a small executive committee, while reference can also be made to the members of an international committee upon which each participating country has one or more representatives. The last congress met in Sweden in 1939 and, apart from all other considerations, that held this year in Switzerland will be memorable for the renewal of old friendships and the opening up of new avenues of scientific intercourse. It was attended by about a hundred and sixty individuals representing twenty-one different nations, and the British group was one of the largest.

The opening session on the first evening, at which formal business tempered by interludes from a first-class string quartette was transacted, was held in the spacious Zurich Congress House. On this occasion Naumann Medals, which are awarded for distinguished services to limnology, were presented to the American Society for Limnology and Oceanography and to the Freshwater Biological Association of the British Empire. The evening concluded with a supper, at which the Swiss organising committee were our hosts, and which served to a remarkable degree to establish contact between the different nationalities present.

The scientific work of the Congress was largely concentrated into the mornings of August 19 and 20 and the morning and afternoon of August 22. On each occasion there were simultaneous sessions concerned with general limnology and with freshwater fisheries, while on August 22 there were other sessions devoted to water utilization and water sanitation. The many short papers read at these various sessions, a considerable number contributed by the British members, covered a wide range of topics. The ecology of river-populations and self-purification in rivers, phytoplankton problems and the fungal parasites of the phytoplankton, the ecology and distribution of diverse freshwater Invertebrata, the regional limnology of Switzerland, seasonal changes at the mud-surface and detritus-drifts in lakes, fish-culture and sex in fish, the chemistry of sewage disposal waters, and the biology of filters were among the numerous subjects discussed. There were also several lectures on major topics. Of quite special interest, in view of its relation to the many lakes visited on the excursions, was the symposium on the recent development and present biological condition of the lakes bordering the Alps, in which Profs. Jaag (Zurich), Baldi (Pallanza), and Ruttner (Lunz) took part. On August 20 Profs. Steinmann (Aarau) and Willer (Hamburg) dealt with the taxonomic problems afforded by the genus *Coregonus*, discourses which proved of great interest even to those not directly concerned with fisheries, while on August 22 F. W. Mohlman (Chicago) gave an account of recent developments in industrial waste disposal. On this, the last evening in Zurich, the Town Council entertained the members of the Congress to dinner.

The excursions, which were designed to illustrate much of the matter that had been discussed during the scientific sessions, were excellently organised and were marked by the lavish hospitality that accompanied them. The afternoons of August 19 and 20 were devoted respectively to a visit to the Cantonal Fish Breeding Station at Stäfa, and to a trip by motor coach to various small lakes in the vicinity of Zurich. The whole of August 21 was taken up by a visit to the falls of the Rhine at Schaffhausen and to the "Untersee" (Lake of Constance), while on August 24 most of the members visited the laboratory on the Jungfraujoch. Both these full-day excursions were favoured by good weather and must have left a deep impression on the participants. On August 23 we travelled from Zurich to Interlaken via Lucerne and the Brünig Pass, making a stay of several hours at Kastanienbaum to visit the small but well-equipped hydrobiological station, originally founded by H. Bachmann and now maintained by the Natural History Society of Lucerne. The latter very generously entertained us to lunch.

The concluding session on August 25 was held at Montreux. Dr. Gunnar Alm (Drottningholm, Sweden) was re-elected president of the Association, while Dr. Rohde (Uppsala) was elected secretary in succession to Prof. Lenz (Plön), who had filled this office since the foundation of the Congress in 1922. It was decided that the next congress should meet in Belgium in 1950, and the ensuing one in Britain in 1952.

It is impossible to say too much in praise of the general organisation that rendered the Congress so unqualified a success, or in acknowledgment of the generosity that made so much available to the members for so small a financial outlay. Among the many Swiss men of science who were concerned, special mention should be made of the head of the Organising Committee, Dr. Huber-Pestalozzi, and of his associates Prof. O. Jaag and Dr. U. Corti, while Mrs. Minder, though never to the front, was a help and guide to all participants.

F. E. Fritsch

SEMICONDUCTORS AND THEIR APPLICATIONS

THE summer meeting of the Manchester and District Branch of the Institute of Physics at the University of Manchester took the form of a two-day conference on semiconductors and their applications. The chairman of the branch, Prof. E. G. Cox (Leeds), presided.

The purpose of the conference was to bring together those working on the fundamental physics of semiconductors, those making such substances commercially, and those applying them in various branches of science and engineering.

The opening session was concerned with the fundamental theory of the behaviour of electrons in semiconductors. Dr. J. W. Mitchell, of the University of Bristol, began by distinguishing between conduction in metals, in semiconductors and in insulators. In semiconductors, conductivity increases with temperature and with the amount of impurity present. The characteristic relation between conductivity, σ, and absolute temperature, T, is

$$\sigma = a\varepsilon^{-E/kT}, \qquad (1)$$

where E is an activation energy. Dr. Mitchell then developed most concisely the wave-mechanical concepts of electrons in ionic crystals and the conditions obtaining in periodic lattices which lead to the splitting of allowed energy-levels for the electrons into large numbers of closely spaced levels, that is, bands. The effects of the presence of defects and impurities in such a lattice were considered, and the distinctions between excess (n-type) and defect (p-type) semiconductors made clear. In the first type, the carriers of charge are electrons, and in the second they are 'positive holes'. For example, sodium chloride when heated to 600° C. in an atmosphere of sodium vapour turns orange, due to the formation of 'F-centres', and at 300° C. under the influence of an electric field the coloration moves towards the anode. With potassium bromide after heating in an atmosphere of bromine, under an applied field the coloration moves toward the cathode. The coloured materials behave as n- and p-type semiconductors respectively. Much of the work on the properties of alkali halides had been carried out by Pohl at Göttingen, and Dr. Mitchell emphasized the importance of such work on relatively simple lattices in gaining an understanding of the behaviour of more complex semiconductors.

Lead sulphide can be given semiconducting properties either by heating in sulphur vapour, in which case it becomes a defect or *p*-type semiconductor, or by heating *in vacuo* (giving an excess semiconductor). Barium oxide when heated in barium vapour turns orange-yellow due to the production of *F*-centres. The oxides of titanium, zinc, cadmium and aluminium when heated *in vacuo*, and cuprous oxide, nickel oxide and uranium dioxide when heated in excess oxygen, all show semiconductor properties. Finally, Dr. Mitchell considered magnetite, a substance the conductivity of which (200 ohm^{-1} cm.$^{-1}$) lies approximately midway between that of a metal and of the average semiconductor. Its unit cell is twice the size of the normal cell and includes 32 oxygen ions and 24 iron ions. Of these 24 iron ions, 16 are ferric and 8 ferrous. Consideration shows that 8 of the ferric ions can be considered as 8 ferrous ions each with an extra electron, thus giving rise to additional energy-levels above the normal filled band and so accounting for its conducting properties.

Dr. R. A. Smith (Telecommunications Research Establishment, Malvern) then followed with a paper dealing principally with conductivity measurements. Previous work indicated that a of equation (1) varies to some extent with amount of impurity, and E varies considerably. Also there is a difference between measurements made on polycrystalline samples and those on single crystals of the same substances. Plots of log σ against $1/T$ give straight lines, the slopes of which decrease with increasing quantity of impurity. In most substances, measurements of Hall coefficients and thermo-electric powers have shown that conductivity is by electrons or by positive holes. For others, notably lead and tin sulphides, conductivity can either be by electrons or positive holes, depending on whether there is excess of metal or electronegative constituent, and near the stoichiometric composition the number of carriers of each type is approximately equal. In the latter case, the conductivity is a minimum and the temperature coefficient a maximum. For polycrystalline materials conductivities range from 10^{-6} to 10^{-2} ohm^{-1} cm.$^{-1}$; but for single crystals the range is 10 to more than 1,000, and the temperature coefficient is small and usually slightly negative. Single crystals thus appear to behave as semi-metals. The difference between single and polycrystalline materials might arise through the presence of intercrystalline barriers, and to investigate this, R. P. Chasmar has made measurements at the Telecommunications Research Establishment on evaporated layers of lead sulphide at radio frequencies up to 50 Mc./s. The results are difficult to interpret, but it appears that at high frequency the temperature coefficient of conductivity is small and negative, while at low frequency it is large and positive.

Dr. G. G. Macfarlane (Telecommunications Research Establishment) spoke about some theoretical aspects of the work done on lead sulphide cells, especially the variation of resistance at low temperature. He explained the form of the resistance-temperature curve by assuming that at low temperatures (below 150° K.) the supply of electrons is constant, independent of temperature, but that their mobility varies with temperature.

Dr. C. J. Milner (B.T.H. Research Laboratory, Rugby) described and demonstrated various recently developed semiconductor devices useful in infra-red work and now available. A 'coolable' type of lead sulphide photoconductive cell with 10 mm. × 1 mm. element size has a detection limit (signal equal to noise for 1 c./s. band-width) of 5×10^{-10} watt at 20° C. and 5×10^{-11} watt at − 80° C. (that is, filled with solid carbon dioxide). At 20° C., peak spectral response is at 2·2 μ and the long wave limit at about 3·0 μ; at − 80° C., 2·8 and 3·4 μ respectively. Bolometers formed of (reduced) magnesium titanate are able to detect about 10^{-8} watt/cm.^{2}; a unit with element size 2 mm. × 0·2 mm., suitable for spectrometer use, has been standardized. The sensitivity of these types of detector in radiation pyrometry is comparable for source temperatures of 100–200° C. Nernst filaments (zirconia rods with platinum leads) operating as radiation sources at 2,000–2,100° C. in free air were also shown.

Dr. Milner referred to the theory of Sosnowski, which explains the experimental result of Starkiewicz and others, that maximum photosensitivity in lead sulphide coincides with zero (overall) thermo-electric power, by identifying this state as that giving maximum frequency of alternation between n- and p-regions. He suggested that the theory also associated high sensitivity with an uneven distribution of impurities, and that this might explain the wide variations encountered in processing evaporated cells.

Dr. R. W. Sillars (Metropolitan-Vickers Electrical Co., Ltd.) gave a paper on non-linear resistors, in which he dealt with the properties of silicon carbide. Polycrystalline silicon carbide bonded by clay showed non-linearity of its current-voltage relationship and other properties quite different from specimens of sintered silicon carbide. Besides demonstrating these properties he outlined methods of using such semiconductors as circuit elements.

Mr. H. Wolfson (Standard Telephones and Cables Co., Ltd.) presented a paper on thermistors in which he began by reminding his audience of the researches of Faraday on the properties of silver sulphide over a hundred years ago, and the development which has taken place up to the present time. The use of silver sulphide was abandoned some years ago because of the occurrence of polarization effects due to ionic conduction and the presence of a 'hysteresis' loop when temperature changes occur. At the present time the most common materials used are the oxides of cobalt, manganese, nickel, iron, chromium and copper. In production, beads of the oxides, mounted on fine platinum wires, are fired in controlled atmospheres. Typical thermistors have a 'half-temperature' of 20° C. at 300° K., that is, a temperature change of 20° C. at 300° K. will double or halve the electrical resistance of the bead. Another type of bead has a cold resistance of 2,000 ohms, but if 20 milliwatts is dissipated in the bead its resistance will fall to 60 ohms. The use of thermistors as circuit elements was described, as well as some of their applications in medical research as temperature indicators.

Dr. H. L. Penman (Rothamsted Experimental Station) described the development of a portable thermistor bridge for micro-meteorology among growing crops. A portable unit had been built to measure temperature, humidity and wind speed among growing potato-crops in connexion with an investigation into factors affecting the spread of virus disease.

Mr. S. L. Martin (Philips Electric, Ltd., London) described recent experiments carried out by Vink on the conductivity of mixed barium and strontium oxides, which were explained in terms of conduction through crystallites in contact and thermionic

emission from crystallite to crystallite. The curve of conductivity as a function of temperature showed three different slopes for the temperature ranges, less than 700°, 700–800°, and above 800° K., the values agreeing with those previously reported. In discussion, the need for consideration of much simpler substances was emphasized as well as the elimination of uncontrollable variables, and it was suggested that magnesium oxide would be the easiest oxide to study since large single crystals have recently become available.

Photo-conductivity of the lead sulphide type of semiconductors attracted some discussion, especially as the literature appeared to indicate that the method of preparation of the lead sulphide films affected considerably their photo-conducting properties. It was suggested that the lead telluride type of cell should be studied since its production does not involve contamination by oxygen, etc.

The final session of the Conference was devoted to an exhibition of properties and applications of semiconductors, many of which had been discussed in the main sessions. A clutch using the Johnson–Rahbeck effect was shown using polished magnesium titanate in contact with polished brass, as well as a lead sulphide cell showing the high temperatures reached at hot spots at frictional contacts.

The papers and discussions made clear the growing interest in the theory and applications of semiconductors, and directed attention to the work proceeding in government, industrial and university laboratories. Some of the papers presented will lead to contributions to other journals.

W. GRATTIDGE
F. A. VICK

SELECTION OF STUDENTS FOR UNIVERSITIES

ON the morning of September 14, Section L (Education) of the British Association discussed "Selection at the University Level". Mr. W. O. Lester Smith, president of the Section, presided.

Mr. J. O. Roach spoke from experience of the Civil Service Selection Board, and previously as a Cambridge tutor. He said that some well-known modern methods of selection depended essentially on a careful job analysis. But in the case of university students, for what were we selecting? For success in examinations, for success in life, or for what? There was no one criterion and therefore no one method of selection. He felt strongly himself that there must on no account whatever be any interference with those of exceptional intellectual powers; no non-academic criterion must be allowed to exclude these. Also he was against a health test—too many men of intellectual distinction had suffered from poor health since the beginning of the world. Forecasts of employability, too, were extremely difficult to make successfully. We must not exaggerate the ill-success of the present method; at least it satisfied public opinion as non-political and generally fair. Still, methods of selection were certainly an important problem, now that there was hope that all, or nearly all, the boys and girls of ability in the nation would reach the sixth forms of schools; and the dissatisfaction with to-day's students expressed by Lord Lindsay of Birker in the House of Lords had met with wide agreement. Mr. Roach emphasized that the need for a new approach was being widely recognized in the universities; and he warned the meeting against assuming that there was any one quick and easy solution to be found.

Mrs. J. L. Stocks found wide agreement among those present with views she had formed from her experience at Westfield College, London. There she had, with very small exceptions, been concerned only with honours women students for arts subjects. She thought that there was a serious danger of paying too much attention to the requirements of the various professions, and too little to the quality of life inside universities. She was herself impressed with the qualities of to-day's women students, who were drawn from a wider range than the students of the '90's, with their cultured, keen but rather narrow backgrounds. In the sixth forms of schools nowadays, the girls had done all sorts of things outside formal classes, from dramatics and foreign visits to conferences on world citizenship and the organising of national savings. They had their shortcomings, of course; some of them, for example, had no idea how to talk to a stranger or how to go away from a party.

As for the present system of selection, Mrs. Stocks said there was rather an absence of system. The anxious queueing for Somerville, Westfield and other residential colleges was a ridiculous arrangement, infuriating for the selectors and very bad indeed for the adolescent selectees. She thought that any better method of selection would be likely to involve some degree of conflict with hitherto accepted individual liberties; but this might have to be accepted. A final solution might well take time to find, as the encouraging success of social democratic education was still a new thing. At all costs, universities must remain academic communities, and not become, for example, mere schools for leadership.

Mr. C. R. Morris spoke as a headmaster. He did not believe that the selection of individual students was the most important problem to-day, urgent as it was. The universities appeared to be dissatisfied with nearly all the students they were admitting, and not just with the small percentage of the total body who might be different if the system of selection were different. As a result, many people seemed to be toying with the idea that able boys ought to continue right up to the age of eighteen with work of the general type of school certificate work. If this were really intended, it would be a very serious mistake. It had been a great triumph on the part of the grammar schools to lead so many good students to the doors of the university and make the present university expansion possible. It must not be supposed that all able boys *wanted* to go to the university. Outside the professional and near-professional classes, this was far from being the case. In the other sections of society, it was the schools which had to do the missionary work, and without doubt it was by their sixth-form courses that they succeeded.

Moreover, this sixth-form work, Mr. Morris claimed, was in principle educationally sound. After reaching the age of fifteen or so, an able boy, whose contemporaries were starting on their working careers, needed to feel that he was beginning to become a real scholar or expert in the group of studies for which he had the best aptitude. This gave him his initiation into the commonwealth of learning. Certainly his work in his special field ought to have a less crowded syllabus than at present and give him more elbow room to explore for himself; and outside

his special field he should give a third of his time and energy to the continued study of the use of English and to the discussion of general problems, cultural, religious and social. Discussion really came to mean something if each boy could contribute to it on the basis of his own expertise and hear his friends do the same. Ideally, sixth-form work, outside the subjects of special choice, should not be subject to external examinations. It was necessary here to exploit idiosyncrasies in the teachers, not to steam-roller them. The most important single thing was a real understanding between teachers and schools, and this would now be perfectly practicable if it were set about in the right way.

In the course of an interesting discussion, Mr. Clegg made the point that local education authorities had in effect asked the universities to organise through the joint matriculation boards the selection of students for financial grants, and the universities were now criticizing the students selected. The remedy, he thought, lay in the hands of the universities themselves.

The president of the British Association, Sir Henry Tizard, said that in his view university teachers should recognize that they were not experts in the education of schoolboys and schoolgirls, and should leave this to the schools. University students must be in the upper range of intelligence and must *want to do something*. Intelligence and zeal—provided students had these virtues on entering the university, it did not matter what subjects they had been taught at school.

A number of speakers emphasized that public opinion did not sufficiently appreciate the part that ought to be played in the higher education of the nation by technical colleges. It was most short-sighted to allow these to continue to fall so far short of the universities in prestige.

MORPHOLOGICAL ASTRONOMY

THE Halley Lecture for 1948, with the above title, was delivered at Oxford on May 12 by Dr. F. Zwicky, of the California Institute of Technology, Pasadena. The lecture covers such a wide range in astronomy that only the more important points can be referred to in this short summary; fuller information can be obtained from *The Observatory* (**68**, 845, August 1948), where it is printed in full.

The morphological method is merely an orderly way of looking at things, and its essence is direct thinking and direct action—a combination which is a great asset of free men and of the democratic way of life. A complete morphological analysis of astronomy is a very comprehensive undertaking, and Dr. Zwicky discusses only some of the basic elements of such an analysis, among which he includes the following: observation of celestial phenomena; experimentation with celestial phenomena; theoretical integration; use of the knowledge gained in construction; dissemination of the knowledge and its bearing on all activities of man.

Under the first of these headings, Dr. Zwicky deals with the instruments to be used for observation and gives a very brief description of the photo-electronic telescope, which has introduced a number of new features. Even with such telescopes of relatively limited definition and light power, the search for novæ, supernovæ, variable stars, comets, meteors, etc., can be put on a 'mass-production' scale because images from photo-electronic telescopes can be televised. Another of the different advantages of this telescope is the ability to steady moving or scintillating images resulting from unsteadiness of the atmosphere or motions in the telescope, and automatic guiding of the telescope can be accomplished through devices similar to those used for steadying the refocused image on the recording surface.

Reference is made to the devices for observing phenomena from points above the main portion of the earth's atmosphere, by the use of rockets carrying scientific instruments. V2 rockets have already carried various instruments to heights exceeding 200 km., and it is proposed increasing this range to 1,000 km. to eliminate the greater portion of the atmospheric absorption. There are visions of vehicles carrying observers to great heights, and even the high-flying conventional aircraft have possibilities in this direction which may some day be exploited.

The accomplishments of the 18-in. Schmidt telescope on Palomar Mountain during the last ten years are dealt with, and important results mentioned refer to work on clusters of nebulæ, nebulæ, stars, supernovæ of various types, common novæ, very blue faint stars, and the general theory of relativity and the theory of the expanding universe. In connexion with this last subject, it was proposed that compact nebulæ acting as gravitational lenses could be used as a check for the deflexion of light, and the idea of nuclear matter of a density of the order 10^{14} gm./c.c. was also suggested. Such matter, which should exist in neutron stars—perhaps ancient remnants of supernovæ—would act as gravitational stars *par excellence*, and it is intended to make a determined search with the 18-in. Schmidt. Bright supernovæ supply data for some interesting conclusions on nuclear chain reactions, knowing that such bodies emit during the first 200 days about 5×10^{49} ergs in the form of visible light. For a star of mass 100 times that of the sun and containing about 10^{59} protons, the energy liberated per proton is, therefore, much greater than the maximum energy liberated per proton in the most energetic chemical reaction. There is, therefore, some justification for the conclusion that in a supernova outburst there is a nuclear chain reaction attended probably with a gravitational collapse to nuclear matter. Some supernovæ, notably the object NGC 4636, have been caught on the rise, and in such cases the speed is in accord with the assumption of nuclear chain reactions. As Zwicky remarks, "We here therefore have one more example how apparently academic astronomical observations led the way to the discovery of phenomena of the greatest import". A short investigation suggests that there is the possibility that cosmic rays are generated in supernovæ.

Astronomical knowledge has been used in the past for the conduct of human affairs, and an extrapolation of these applications, which lies in the line of morphological thinking, is a reconstruction of the universe, in which that of the earth comes first. This is of fundamental importance as there is the danger that the whole earth might be exploded by large-scale nuclear chain reaction, and schemes for stabilizing the earth against such an eventuality are part of morphological astronomy. Possibly there will also be plans for making some of the planets habitable by changing them intrinsically and by altering their positions relative to the sun; and however fantastic such schemes may seem, Zwicky suggests that these

thoughts are nearer to scientific analysis and mastery than were Jules Verne's dreams in his time.

The aim of the universities is to produce astronomers, chemists and so on; but this approach has failed us, especially if it is admitted that the purpose of education is the creation of realities that are in agreement with the avowed purpose of man. The purposes have frequently been stated, but the actualities present a state of affairs in which it is often difficult to recognize them. In the morphological reconstruction of human society and the material universe, astronomy and astronomers may be destined to play an important part.

SOCIAL SCIENCES AND INDUSTRIAL PRODUCTIVITY

BESIDES discussing the place of science in government and scientific man-power (see *Nature* of August 7, p. 199), the first annual report of the Advisory Council on Scientific Policy gives some account of the work of the committee set up to report to the Advisory Council regarding the directions in which a scientific approach is most likely to promote an increase in the national productivity. In an interim report submitted in September 1947, the committee concluded that current fundamental research in the physical and biological sciences was unlikely to have any material short-term effect in increasing productivity, whatever might emerge from its results in future. For short-term results the more effective application of scientific knowledge already available was likely to prove much more fruitful; but for this an adequate supply of qualified technologists and engineers is essential. The committee recommended that steps should be taken immediately to ensure that this demand is met. It was also suggested that the type of approach used so successfully by the Services during the War and commonly described as 'operational research' might also be very fruitful in yielding rapid results. Publication of a book on operational research was recommended and its preparation is in hand. The committee also suggested that it is important to try to establish scientifically whether the quantity and quality of the existing rations are likely to diminish the worker's potential outlook. Later, it strongly recommended the energetic pursuit of research on the nutritional consumption and physiological requirements of the main occupational classes in the United Kingdom, as well as obtaining relevant data from abroad, particularly from the United States and from the British Zone of Germany.

The Committee on Research and Productivity also appointed a special sub-committee to review existing technical information services and to consider their improvement. The work of this sub-committee was afterwards transferred to a Panel of the Committee on Industrial Productivity. It has been decided that the Information Unit in the Intelligence Division of the Department of Scientific and Industrial Research should be expanded to provide a national service for putting inquirers into touch with sources of specialist information. The possibility of achieving rapid results by the application of sociological principles was likewise explored. A memorandum issued on the human factor in production recommended a review of existing knowledge in this field, more effective co-ordination of the work being carried out by different bodies and further research into the basic conditions of good morale and efficient organisation, the characteristics of successful joint production committees, the status and position of the foreman, the differences of response as between male and female operatives, and the selection and training of managerial staff. It emerged in this general inquiry that the concrete objective of raising the level of the least efficient firms nearer to the level of the most efficient would go a long way towards effecting the general rise of ten per cent in overall output by British industry for which the Government had asked. The functions of this Committee have now, as announced last December, been transferred to the new Committee on Industrial Productivity, which, with its four subsidiary panels, is continuing and extending the work initiated under the Advisory Council.

This new Committee is quite independent of the Advisory Council on Scientific Policy, but Sir Henry Tizard is chairman of this Committee also, and three other members of the Advisory Council are also serving on it. Two of the panels under this Committee are continuing the earlier investigations into the potentialities of operational and sociological research, and a statement has recently been issued from the Economic Information Unit of the Treasury on the work of the Panel on Human Factors, of which Sir George Schuster is chairman. The Panel was constituted "to advise the Committee concerning the directions in which productivity could be increased by the application of research into the human factors in industry and to make recommendations for further researches into this field where called for". At its first meeting on February 2, 1948, the Panel decided to establish a research advisory group of representatives of the Medical Research Council, independent institutions engaged in research in the social sciences and departments of applied psychology in certain universities to advise the Panel on matters of research and on the availability of research workers.

The Panel was impressed at an early stage by the lack of workers with practical experience in the field of the social sciences, and has considered the means by which the number of workers could be increased and their training undertaken. In the meantime, it was decided to arrange for existing research institutions to undertake a series of investigations selected so as to cover points where it is important to acquire more scientific knowledge and so as to provide opportunities to train additional field-workers. The statement lists a number of projects which have thus been inaugurated, and the responsibility for supervising their completion and for making grants towards their costs has been undertaken by the Medical Research Council. In addition to these projects, certain activities of the British Institute of Management have been co-ordinated with the programme of the Panel, and a number of further projects from university departments are being considered.

The projects approved include studies of productivity in the Royal Ordnance Factories by the Industrial Health Research Board, and of work, design and the measurement of human performance by the Cambridge Applied Psychology Unit. The Tavistock Institute of Human Relations is investigating within an engineering firm the effect of different methods of payment, joint consultation procedures, methods of communication within the firm and inter-management relations, and is also examining methods of disseminating knowledge by group discussion, films, radio, etc. The Nuffield Research Unit, Cambridge,

has undertaken an investigation of the effects of ageing on productivity.

Since this statement was issued, some further information has been given by the National Institute of Industrial Psychology regarding the three research projects it is undertaking for the Panel. The first of these, on problems associated with the selection and training of foremen, includes a survey of present practice and of the status of foremen relative to the middle and higher levels of management. It is hoped that the survey will show how far recent advances are being utilized in industry, and that it will also provide material for a comprehensive job study on which to base further improvements in technique. Later it is proposed to carry out experiments to evaluate methods of selection and training under controlled conditions.

The second project is a study of methods of joint consultation in industry generally; by a survey of existing practice the Institute hopes to ascertain how many firms use consultative machinery and how effective it seems to management and men. Further work is planned to compare the effectiveness of various methods of consultation. A third study, of the effect on production of the size of unit of work, is intended to determine how far increase of job-breakdown reduces the will to work and how output varies with the size of batch handled in repetitive work.

Having inaugurated these projects, the Panel has turned its attention to more direct methods for improving industrial productivity by the wider adoption of techniques in the field of management and human relations which have already proved valuable. The projects already launched, however, besides providing for the study of a number of key factors affecting production, should serve as an experiment in a co-ordinated programme of allied research to be undertaken by a number of different organisations, and should build up a coherent body of research workers and thus increase the available strength for expanding field investigations. It is also hoped that interim conclusions may be drawn from the studies and applied as the work proceeds, even if the completion of the projects takes some time.

The Panel has clearly made a good start on the foundations laid by the Committee on Research and Productivity of the Advisory Council on Scientific Policy. Much remains to be done, for example, on the administrative side, where the responsibility of the Medical Research Council can scarcely be regarded as more than a temporary expedient while some satisfactory permanent scheme for financing and watching over the research projects for the Panel is elaborated. Nevertheless, a start has been made towards meeting the need for team work in this field on which *Planning* laid such stress in its recent broadsheet on the human factor (see *Nature*, **161**, 780; 1948), and it is interesting to note how largely the projects already initiated cover the suggestions made there.

Success in this field, as *Planning* rightly stresses, is essentially a matter of team-work, in which the leader of each team must have at his disposal a wider variety of scientific techniques and disciplines than can be compassed by even two or three workers. The central discipline involved is probably psychology, or one of a closely related group including psychiatry and industrial medicine. Experience in and some understanding of management or administration, as well as knowledge of the technical side of the industry under observation, are also important, as well as a high grade of understanding of such social sciences as economics and social anthropology. Inevitably, too, work of this kind demands ability in collecting and analysing statistics.

The second main point made in this broadsheet is that research should be done on the spot in industry, and it is clear that Sir George Schuster and his colleagues are already proceeding on such lines so far as the limited number of qualified workers permits, and that they are seeking to expand as swiftly as possible the number of trained workers necessary for such field-work on any considerable scale. We may be equally confident that the researches they are fostering will have regard to the third main point made by *Planning*, that the research should treat the industrial unit under observation as a functional whole, studying particular factors not in isolation but as elements in a total situation. The greater co-ordination between the research bodies themselves—including firms undertaking investigations on their own behalf—which the work of the Panel will promote will lead to improved methods both in the collection of data and in analysis, and it may be confidently expected that better arrangements will be made in the future than at present exist for the pooling of information as well as for the correlation of data.

Following the lead of the Advisory Council, Sir George Schuster and his colleagues have got to work swiftly on sound lines. The progress of their work will be followed with keen interest, as discussions at the recent meetings of both the British Medical Association and the British Association testify. There is growing appreciation that the informal social group lies at the bottom of any informal organisation and is the basis on which a good administrative structure must be built. The work of the Panel on Human Factors and indeed all the work of the Committee on Industrial Productivity can be counted upon to make even more widely known such results as those of the Hawthorne experiment, and to assist in overcoming the resistance of employers and of trade unions alike to the whole principle of scientific study and to the application of its conclusions.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 18

BRITISH MUSEUM (at the Natural History Museum, Cromwell Road, London, S.W.7), at 2.30 p.m.—Dr. J. Ramsbottom: "Edible Fungi".* (Further Lectures on Friday, October 22, Monday, October 25, and Friday, October 29.)

UNIVERSITY COLLEGE, LONDON, DEPARTMENT OF BIOCHEMISTRY (in the Physiology Theatre, Gower Street, London, W.C.1), at 4.45 p.m.—Dr. E. M. Crook: "The Electron Microscope and its Biological Applications".* (Further Lectures will be given on October 25 and November 8.)

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. S. Morse: "Recent Developments in High Vacuum Technology".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the INSTITUTE OF SEWAGE PURIFICATION, at the County Technical College, Essex Road, Dartford), at 6.30 p.m.—Mr. A. E. J. Pettett: "Effect of Cyanides on Treatment of Sewage in Percolating Filters".

Tuesday, October 19

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Mr. J. T. Edwards: "Chemical Control of Protozoan Parasites".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "What should be the Design Considerations of Services' Radio Equipment ?" (to be opened by Mr. S. J. Moss and Mr. G. C. F. Whittaker).

CHEMICAL SOCIETY, SOUTHAMPTON BRANCH (joint meeting with the PORTSMOUTH AND DISTRICT CHEMICAL SOCIETY, in the Municipal College, Portsmouth), at 7 p.m.—Dr. F. P. Bowden, F.R.S.: "Tribochemistry and the Initiation of Explosives".

Wednesday, October 20

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. C. O. Boyse: Inaugural Address as Chairman.

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the LONDON SECTION of the SOCIETY OF CHEMICAL INDUSTRY, at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 6.30 p.m.—Dr. J. G. Fife: "Protection of Chemical Inventions".

ROYAL STATISTICAL SOCIETY, NORTH-EASTERN GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the Chemical Industries Club, 18 Lovain Place, Newcastle-upon-Tyne), at 6.30 p.m.—Dr. B. P. Dudding: "A Statistical Contribution to Production Economy".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "Science and Peace" (to be opened by Prof. J. D. Bernal, F.R.S., and Prof. N. F. Mott, F.R.S.).

IRISH CHEMICAL ASSOCIATION (in the Department of Chemistry, Trinity College, Dublin), at 7.45 p.m.—Prof. T. S. Wheeler: "The Training of a Chemist" (Presidential Address).

Thursday, October 21

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. A. M. Bensusan: "Notes on a Small Working in Southern Rhodesia"; Messrs. E. J. Pryor and K.-B. Liou: "A Simple Flotation Cell".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6 p.m.—Annual General Meeting; Mr. L. H. Bedford: Presidential Address.

CHEMICAL SOCIETY, HULL BRANCH (joint meeting with the LOCAL SECTION of the OIL AND COLOUR CHEMISTS' ASSOCIATION and the UNIVERSITY COLLEGE SCIENTIFIC SOCIETY, in the Science Lecture Theatre, University College, Hull), at 6 p.m.—Dr. A. E. Alexander: "Surface Chemistry—its Achievements and its Future".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. G. W. Wilson and Squadron-Leader E. P. Bridgland: "Cold Weather Operation of Aircraft".

TEXTILE INSTITUTE (at 16 St. Mary's Parsonage, Manchester), at 7.15 p.m.—Mr. H. W. Best-Gordon: "Chemical Aids to Textile Processing and Finishing".

TEXTILE INSTITUTE, YORKSHIRE SECTION (at the University, Leeds), at 7.15 p.m.—Mr. E. V. Giles: "Application of Plastics to the Textile Industry".

CHEMICAL SOCIETY, EDINBURGH BRANCH (joint meeting with the LOCAL SECTIONS of the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, at the North British Station Hotel, Edinburgh), at 7.30 p.m.—Prof. J. W. Cook, F.R.S.: "Some Aspects of the Chemistry and Biochemistry of Polycyclic Aromatic Hydrocarbons".

Friday, October 22

CHEMICAL SOCIETY, BIRMINGHAM BRANCH (joint meeting with the UNIVERSITY OF BIRMINGHAM CHEMICAL SOCIETY, in the Main Lecture Theatre, Chemistry Department, The University, Edgbaston, Birmingham), at 4.30 p.m.—Sir Cyril Hinshelwood, F.R.S.: "Cell Growth Phenomena and Chemical Kinetics".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion.

MANCHESTER STATISTICAL SOCIETY, STATISTICAL METHODS STUDY GROUP (at the Society of Architects, 16 St. Mary's Parsonage, Manchester), at 5.30 p.m.—Mr. W. A. B. Hopkin: "Some Problems of Population Statistics".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Capt. (E.) W. Gregson: Presidential Address.

INSTITUTE OF PHYSICS, MANCHESTER AND DISTRICT BRANCH (in the New Physics Theatre, The University, Manchester), at 7 p.m.—Mr. H. L. Kirke: "Studio Acoustics and Modern Methods of Measurement".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR LECTURER IN ANATOMY—The Secretary of University Court, The University, Glasgow (October 23).

GRADUATE ASSISTANT CHEMIST in the Laboratory, Rookery Park, Erdington, Birmingham, to carry out work concerned with sewage purification—The Clerk to the Birmingham Tame and Rea District Drainage Board, 117 Colmore Row, Birmingham 3 (October 23).

SENIOR LECTURER IN SOILS AND FERTILIZERS at the Canterbury Agricultural College, Lincoln, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (October 25).

PRINCIPAL OF THE SHROPSHIRE FARM INSTITUTE—The Secretary for Education, Education Office, County Buildings, Princess Street, Shrewsbury (October 30).

LECTURER or an ASSISTANT LECTURER IN STRUCTURAL ENGINEERING—The Registrar, College of Technology, Manchester 1 (November 1).

ANALYSTS for the analysis of samples of drugs and medicines taken on test prescriptions dispensed by pharmacists and authorized sellers of poisons under Part IV of the National Health Service Act 1946—The Chief Pharmacist, Ministry of Health, Whitehall, London, S.W.1 (November 1).

CHAIRS OF MINING, MECHANICAL, ELECTRICAL, and CIVIL ENGINEERING, in the New South Wales Technical University—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (November 1).

FOUNDATION CHAIR OF CHEMICAL ENGINEERING in the New South Wales Institute of Technology (Technical University)—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (November 1).

POULTRY OFFICERS (2, male) IN THE DEPARTMENT OF AGRICULTURE AND LANDS—The Secretary, Government of Southern Rhodesia, Rhodesia House, 429 Strand, London, W.C.2 (November 3).

SENIOR SCIENTIFIC OFFICER in the Ministry of Supply at the Atomic Energy Research Establishment, Harwell—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2298 (November 4).

EXPERIMENTAL OFFICERS IN THE CHEMICAL INSPECTORATE (Atomic Energy), Ministry of Supply—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2297 (November 4).

LECTURER IN ANATOMY—The Registrar, King's College, Strand, London, W.C.2 (November 8).

SENIOR ASSISTANT IN PHYSICS—The Secretary, South-East London Technical College, Lewisham Way, London, S.E.4 (November 13).

LECTURER IN BIOLOGY at the New England University (University of Sydney), Armidale, N.S.W.—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (November 15).

LECTURER IN THE DEPARTMENT OF GEOGRAPHY of the Natal University College, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (November 30).

LECTURER IN BOTANY (plant physiology)—The Registrar, University College, Southampton (November 30).

LECTURER IN CHEMISTRY in the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (December 1).

LECTURER IN ECONOMIC STATISTICS in the Faculty of Economics of the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (Sydney, December 31).

SENIOR LETURER IN BOTANY at Rhodes University College, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (December 31).

PLANT PATHOLOGIST in the West African Cocoa Research Institute, Gold Coast, to undertake investigation into the diseases of cocoa—The Director of Recruitment, Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1.

LECTURER IN CHEMISTRY—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

HEAD OF THE SCIENCE DEPARTMENT—The Headmaster, Clifton College, Bristol 8.

HONOURS GRADUATE for training as a Fish Processing Expert—The Under-Secretary of State, Colonial Office (Research Department), Sanctuary Buildings, Great Smith Street, London, S.W.1.

LECTURER IN THE MATHEMATICS DEPARTMENT—The Principal, Northampton Polytechnic, St. John Street, London, E.C.1.

RESEARCH BURSARY IN THE CHEMISTRY DEPARTMENT of the Imperial College of Science and Technology, for fundamental research on the physical chemistry of high-temperature reactions involving iron—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

LABORATORY STEWARD IN THE DEPARTMENT OF BIOLOGY—The Principal, Technical College, Brighton.

LABORATORY ASSISTANT (man) for biology, chemistry and physics laboratories, at George Green's School, East India Dock Road, Poplar, London, E.14—The Education Officer (Estab. 2), County Hall, Westminster Bridge, London, S.E.1.

JUNIOR STUDENT LABORATORY TECHNICIAN (Grade C) IN THE DEPARTMENT OF MORBID ANATOMY—The House Governor, St. Mary's Hospital, London, W.2.

LABORATORY TECHNICIAN (Grade III) IN THE DEPARTMENT OF PHARMACOLOGY—The Secretary, University College, Gower Street, London, W.C.1, quoting "Pharma/1".

LABORATORY ASSISTANT to take charge of the work in either the physics or chemistry laboratories—The Bursar, The College, Cheltenham.

CHEMIST by the East African Industrial Management Board, Nairobi—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.21789/3E.

TECHNICIAN IN THE MOZELLE SASSOON SUPER VOLTAGE X-RAY THERAPY DEPARTMENT—The Clerk to the Governors, St. Bartholomew's Hospital, West Smithfield, London, E.C.1, endorsed 'Technician'.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Catalogues

Chance Optical Glass. Pp. 14+7 plates. (Smethwick: Chance Brothers, Ltd., 1948.)

Periodica: a Catalogue of Periodicals and Journals, Proceedings and Transactions of Institutions and Academies, both British and Foreign, and also an Extensive Radio Library. (Summer Catalogue.) Pp. 80. (London: Wm. Dawson and Sons, Ltd., 1948.)